VOLUME 86 JANUARY, 1948 NUMBER 1

CONTENTS

The Influence of Vitamin E on Vascular Disease. *Evan V. Shute, B.A., M.B., F.R.C.S.C., Arthur B. Vogelsang, B.A., M.D., Floyd R. Skelton, M.D., London, Canada, and Wilfred E. Shute, B.A., M.D., Guelph, Canada* 1

The Visceral Endopelvic Fascia and the Hypogastric Sheath. *Eduard Uhlenhuth, Ph.D., Edward C. Day, M.D., R. Dale Smith, Ph.D., and Edmund B. Middleton, Baltimore, Maryland* 9

The Heterologous Growth of Cancer of the Human Prostate. *Michael S. Hovenanian, M.D., and Clyde L. Deming, M.D., F.A.C.S., New Haven, Connecticut* ... 29

Study of Ureteral Blood Supply and its Bearing on Necrosis of the Ureter Following the Wertheim Operation. *John P. Michaels, M.D., New Orleans, Louisiana* ... 36

Hypertrophic Pyloric Stenosis. *Arthur A. Schaefer, M.D., F.A.C.S., and John Erbes, M.D., Milwaukee, Wisconsin* 45

Infrared Photographic Study of the Superficial Veins of the Thorax in Relation to Breast Tumors; a Preliminary Report. *Leo C. Massopust, Milwaukee, Wisconsin* 54

Repair in the Normal and Hyperacid Stomach; an Experimental Study. *Philip B. Price, M.D., F.A.C.S., Salt Lake City, Utah* 59

Painful Heels in Children. *E. S. R. Hughes, M.D., M.S., F.R.C.S., Oxford, England.* 64

Acute Pancreatitis; a Statistical Review of 307 Established Cases of Acute Pancreatitis. *John R. Paxton, M.D., F.A.C.S., and J. Howard Payne, M.D., Los Angeles, California* 69

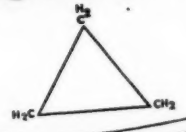
Causalgia: I. The Rôle of Sympathetic Interruption in Treatment. *Harris B. Shumacker, Jr., New Haven, Connecticut, I. Joshua Speigel, Chicago, Illinois, and Richard H. Upjohn, Salem, Oregon* 76

Evaluation of Treatment of Slipping of the Capital Femoral Epiphysis. *Ignacio Ponseti, M.D., and Chester K. Barta, M.D., Iowa City, Iowa* 87

Selection of Operative Procedure to Avoid Colostomy in Carcinoma of Rectum and Rectosigmoid. *R. Russell Best, M.D., F.A.C.S., Omaha, Nebraska* 98

CONTENTS CONTINUED ON PAGE 5

"Ohio" CYCLOPROPANE



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CONTENTS FOR JANUARY, 1948—CONTINUED

Tissue Protein Depletion; a Factor in Wound Disruption. *S. Arthur Localio, M.D., Med. Dsc., James L. Chassin, M.D., and J. William Hinton, M.D., New York, New York* 107

EDITORIALS

Vagotomy. *James T. Priestley, M.D., F.A.C.S., Rochester, Minnesota* 114

The Nurse Anesthetist. *Henry K. Beecher, M.D., Boston, Massachusetts* 115

THE SURGEON'S LIBRARY

THE BOOK SHELF

The Cancer of Destiny. *Esther H. Vincent, Evanston, Illinois* 119

REVIEWS OF NEW BOOKS

Neurosyphilis. By H. Houston Merritt, Raymond D. Adams, and Harry C. Solomons 124

Penicillin in Syphilis. By Joseph Earle Moore 124

Human Gastric Function; an Experimental Study of a Man and His Stomach. By Stewart Wolf and Harold G. Wolff ... 125

Medical Disorders of the Locomotor System Including the Rheumatic Diseases. By Ernest Fletcher 125

Les thyroidectomisés. By R. Leibovici and Gilbert-Dreyfus 126

Chirurgie fonctionnelle gynécologique. By R. Bourg 126

Osteotomy of the Long Bones. By Henry Milch 126

May's Manual of Diseases of the Eye. Edited by Charles A. Perera 126

Endocrinology of Neoplastic Diseases; a Symposium by Eighteen Authors. Edited by G. H. Twombly and George T. Pack 127

Books Received 127

CORRESPONDENCE

Abuse of the Term "Subtotal Gastrectomy". *Richard Lewisohn, M.D., F.A.C.S., New York, New York* 128

INTERNATIONAL ABSTRACTS OF SURGERY

Contents ..... i-viii

Collective Review: Carcinoma of the Parathyroid Glands, with a Preliminary Report of 3 Cases. *Edgar H. Norris, M.D., F.A.C.S., Boston, Massachusetts* .. 1

Abstracts of Important Contributions in the Current Surgical Literature 22–104

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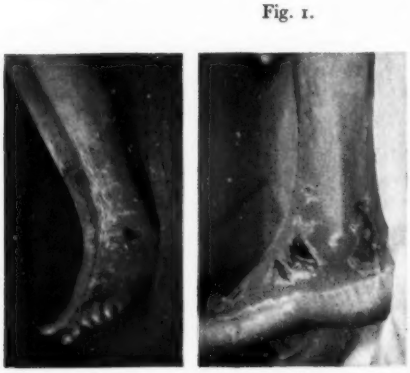
Fig. 1.

Fig. 2.



a b

c

Fig. 3.

Fig. 1. Case 7. Indolent ulcer before, a, and on the 10th, b, and, c, the 30th day of treatment.
Fig. 2. Case 10. Thromboangiitis obliterans on the 20th day of treatment, showing the healed ulcer of the stump.
Fig. 3. Case 8. Early gangrene of the feet before, a, and, b, on the 15th, and, c, 28th days of treatment.

The Influence of Vitamin E on Vascular Disease.—Evan V. Shute, Arthur B. Vogelsang, Floyd R. Skelton, and Wilfrid E. Shute.

SURGERY
GYNECOLOGY AND OBSTETRICS

VOLUME 86 JANUARY, 1948 NUMBER 1

THE INFLUENCE OF VITAMIN E ON VASCULAR DISEASE

EVAN V. SHUTE, B.A., M.B., F.R.C.S.C.,
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IN 1942 Mason (2) reported that the classical fetal resorption in E-deficient pregnant rats was due to such vascular abnormalities in the uterine wall as stasis, distention, and thrombosis (notably venous). Occasionally these conditions terminated in ruptures into the decidua with frank hemorrhage. In E-deficient chicks analogous phenomena are also seen, and there is some evidence in them, too, of functional alteration of the capillary walls.

At about the same time Shute (6) stated that senile vulvovaginitis treated with high doses of the tocopherols often was clinically improved. Biopsy of vulvar tissue after such treatment revealed an appearance suggesting either the proliferation of new capillaries or the reopening of old collapsed capillaries. But the definite lag of 2 to 4 weeks before improvement showed itself suggested the former as being the more likely. On *a priori* physiological grounds it was the more tenable explanation, too.

Mason (3) has also pointed out that in both the monkey and hamster vascular degeneration is a prominent feature in the picture of prolonged vitamin E deficiency. Shute (8) has recently reported the rapid response to intensive tocopherol therapy of 3 patients with acute hemorrhagic nephritis, indicating an effect on the glomerular capillaries. Other observations (7, 11) we have made on the purpuras indicate that the tocopherols decrease capillary permeability and increase low platelet counts. However, it was the influence of the tocopherols on coronary thrombosis and other cardiac processes (1, 3, 14, 15) that recently turned our attention directly to the effect of tocopherols upon pathological conditions of the vascular system. It was noted that many arteriosclerotic cardiacs given tocopherols reported that feet and hands that had been cold and numb for years had suddenly become warm again. Many had had small indolent ulcers which now healed rapidly. We could scarcely fail to investigate certain types of peripheral vascular disease in following up such clues.

This publication was made possible by grants from the Shute Foundation for Medical Research.

CLINICAL STUDIES

What follows is an account of our experiences with tocopherol therapy in a series of patients having vascular disease.

Thrombophlebitis and phlebothrombosis. Twenty-two cases of this condition have been studied. Three typical examples will be described briefly.

CASE 1. Miss M. (courtesy Dr. R. Schram), aged 20 years. This girl developed an acute left femoral thrombophlebitis May 28, 1946, the third day postpartum. The area involved was about 4 inches long in the left midthigh, and there was at the same time a phlebitic mass 3 centimeters in diameter in the left

groin. There was a fever of 100.4 to 101.6 degrees, and a platelet count of 80,000. After May 31 the patient was given a daily oral dose of 200 milligrams of α tocopherol acetate. The temperature fell to normal and remained normal after June 1. By June 3 the phlebitic area in the thigh looked as one would expect it to appear after 10 to 14 days of the classical therapy with heat, elevation, and rest. The redness, and almost all the heat and tenderness, had disappeared from the inflamed area. The mass at the groin was then only half its original size and much less red and tender. The platelet count was 136,000 on June 6. Improvement in the phlebitic thigh was rapid and continuous, but not so rapid in the mass in the groin. Her platelet count on June 10 was 176,000. After 2 more weeks the mass in the groin had disappeared, however, and the patient went home on June 26, 1946.

This was the first case of thrombophlebitis treated by us.

CASE 2. Mrs. R., aged 26 years. This woman had suffered from severely varicosed legs for years. On February 24, 1947, in the 8th month of her fifth pregnancy, she presented herself with the most severe and extensive antepartum thrombophlebitis ever seen by us. The femoral and internal saphenous veins of the left lower extremity were involved from midthigh to midleg, and a thrombosed, inflamed varix just above the knee was as large as a man's clenched fist. An area of redness extended for 2 inches on each side of the vein in the thigh. Her temperature was 98 degrees, her platelet count 96,000. She was promptly sent to hospital. In 3 days' time she was greatly improved and left the hospital in good condition in 10 days. Her platelet counts were 96,000 on February 25, 1947 and 132,000 on March 1. She went home with a sedimentation rate of 86, however. Her sole treatment throughout was bed rest, and 250 to 300 milligrams of α tocopherol per day by mouth. She was sent home on 100 milligrams per day. She delivered normally on March 21, 1947. At labor her platelet count was 100,000. There was no recurrence of her phlebitis afterward, perhaps because she was given 300 milligrams of α tocopherol per day during her puerperium.

CASE 3. Mrs. F., aged 37 years. At 36 weeks of her second pregnancy this woman appeared to have a huge hydramnios. It was impossible to induce her *per vaginam* because of an almost inaccessible, rigidly closed cervix. At cesarean section on March 3, 1947 the uterus was found to be small, however, and a child weighing 5 pounds 6 ounces was delivered. But an enormous malignant right pseudomucinous cystadenoma of the ovary (secondary in nature!) was found filling the whole right side of the abdomen, extending up to the liver and far across the left side of the midline. It was adherent generally to the whole ascending colon, much of the inferior aspect of the liver, and to numerous loops of the ileum posteriorly. The patient ran a comparatively easy and afebrile postoperative course for 10 days, although she was flatulent. On March 13 the platelet count was 266,000. That day she developed an acute sepsis, and repeated daily blood cultures showed a hemolytic Bacillus coli. On the same day the whole left lower extremity suddenly developed a typical phlebothrombosis. There was no local heat or redness but some linear tenderness, some edema, and Homans' sign. At once she was given α tocopherol orally in doses of 300 milligrams per day. At the end of 3 days there was absolutely no evidence that there had ever been a thrombosis of that extremity, and the patient moved it in bed with maximum freedom. Because she was nauseated, the tocopherol was discontinued. The next day she suddenly developed a pulmonary embolus in the right base, accompanied by severe dyspnea necessitating an oxygen tent. Her platelet count on March 17 was 200,000. She remained so nauseated that she refused all food and medication, and was carried along for several days on transfusions, intravenous saline and streptomycin. Two days after the tocopherol was discontinued both legs became very edematous generally, with some slight tenderness over the left calf. The platelet count was 156,000 on March 21. In a few days she began to eat and could take tocopherol capsules again. She made a tedious recovery, however. The legs suddenly returned to near normal appearance on April 4 and at the same time her low-grade fever disappeared. On April 6 her platelet count was 360,000. She was sent home taking tocopherol, but no iron of course. Her legs have been normal since. On April 16 she got out of bed for the first time.

All the other patients did as well as those described above.

We have ascribed the results achieved in thrombosis of the veins, with or without attendant inflammation, to a direct effect of the tocopherols on thrombi. There seems to be little doubt that in a fresh thrombosis the clot itself is directly attacked. It can literally melt away, as in the last patient described above. But in thrombophlebitis a thick thrombus can be felt long after all evidences of inflammation other than an elevation of the sedimentation rate have disappeared. Resolution always seems to begin and to progress uniformly over thrombotic areas of any length. Any associated fever usually falls promptly. The possibility of embolism following unduly rapid resolution of a fresh phlebothrombosis must be borne in mind, of course. Perhaps in such cases a small dose of tocopherols and a more gradual response would be desirable.

Fresh thrombi are often associated with a low platelet count, as if the fresh fibrin plug had formed a screen to take a large share of

the platelets out of circulation. Clinical improvement in these patients is coincident with a rise in platelet count and an apparent resorption of the fibrin mesh. On the other hand, older and organized thrombi are usually associated with higher platelet counts, do not seem to screen out platelets, and do not respond to the same dosage of tocopherols. Perhaps double the usual dose is required—often as high as 600 milligrams of the alpha form. Can it be that tocopherols attack fibrin directly by a proteolytic process? A decrease of platelets and a persisting high sedimentation rate on tocopherol therapy is an indication either of recurrence or extension, and demands an increased dose.

The bearing of these observations upon our views on cerebral and coronary thrombosis is too obvious to be labored here, of course.

Should all puerperal women be given tocopherols in an effort to avoid thrombosis? Such therapy might also promote lactation in a few such women (5), but of course should not be instituted until the third day, at least in toxemic mothers, for fear of precipitating eclamptic convulsions (9). Many herniotomies and pelvic operations might benefit similarly from prophylactic dosage.

Indolent ulcers of the leg and ankle. We have studied 13 of these and will describe 4 typical examples:

CASE 4. Mr. H., aged 63 years, a railway news agent. His right leg had been ulcerated at the ankle off and on for 19 years. There was considerable generalized arteriosclerosis, and a normal blood sugar. The present exacerbation dated from 1945. When first seen by us on September 16, 1946, he had been in bed for a month with the right leg literally covered from toe to knee with old and recent open ulcers of all sizes up to 2 inches in diameter. During that month he had been treated with local applications with little or no relief. He was promptly given 250 milligrams of α tocopherol per day by mouth. He began to show improvement in 7 days' time, was nearly healed in 8 weeks, and was completely healed in 10 weeks. He returned to work November 16, 1946, and has been well since, working on the railroad again.

CASE 5. Mrs. C., aged 76 years, a widow living alone. For 18 years she had had recurrent varicose ulcers of both lower legs. She came under our observation on December 13, 1946, for a fundus carcinoma. It was incidentally noticed at that time that her left leg was in an Unna's boot. Both shins were badly scarred from old ulcerations. She had had an indolent varicose ulcer over the left internal malleolus for the previous 6 months, and had worn an Unna's boot during that period of time without much benefit.

The boot was removed, she was curetted and given deep roentgen therapy, and kept in bed. After December 14 she was given 300 milligrams of α tocopherol per day by mouth. In 10 days' time the old ulcer had greatly improved and in 17 days was well healed. The leg has remained well since. She was discharged February 2, 1947. She is now quite active, doing her own housework.

CASE 6. Mrs. A., aged 82 years, had suffered from varicose veins of both legs since 20 years of age. She had had varicose ulcers occasionally since 30 years of age, the last one appearing in 1938. The present episode began in August, 1946. When first seen by us on December 7, 1946, there was a typical varicose ulcer over the internal malleolus of the left ankle. It was 3 centimeters in diameter with a dirty, sloughing base. Several tiny ulcers were to be seen over the external malleolus of the same leg. Her urine was normal. She was put to bed for 9 days and given 300 milligrams per day of α tocopherol. There was so much improvement in the ulcer in that time that she was allowed up. By the 23rd day of treatment the ulcers were greatly improved and healing was complete on the 29th day. She has been well and active since.

CASE 7. Mrs. C., aged 54 years. This woman had been troubled with varices in the left leg since 1922. At that time she had had a venous ligation done. She had had phlebitis five times since, once in both legs. In 1941 an ulcer developed over the left internal malleolus and it had never healed completely since. For the past 3 years it had covered the mesial and anterior aspect of the lower leg and when she presented herself it was about 4 inches in diameter, square in contour, with a stinking, sloughing base.

She was admitted to hospital March 8, 1947. Her blood and urine were normal. She was afebrile. The usual local treatment was applied and penicillin was used as well, both intramuscularly and locally. On March 18 one of us suggested that the penicillin be discontinued and that she be given 375 milligrams of α tocopherol per day by mouth. She made steady and rapid progress thereafter, getting out of bed after March 21. By March 25 the slough had all cleared away from the surface of the ulcer, the odor had gone, fresh granulation covered the whole base, and peninsulas of epithelial tissue had grown in over the granular surface for as much as 1 centimeter in many places. By March 30 the epithelization had progressed considerably, in some places encroaching 3 centimeters or more into the ulcerated area. She was discharged from hospital on April 12.

She was next seen on April 26 at which time the ulcer was well healed except for an area at the center 3 centimeters in diameter. This was reduced to half this size by June 3. On July 20 the ulcer was completely healed.

All the other patients did as well as those described here.

The response achieved in these patients was both prompt and lasting. It was ascribed to an improvement in local arteriolar circulation and to better oxygen utilization by the local tissues. During treatment the affected extremity sometimes became warmer than its mate.

These studies may bear on the problems of plastic surgery.

Early gangrene of the extremities. We have studied 3 such cases and will describe one of them in detail:

CASE 8. Mr. McK. (courtesy Dr. W. Hambly) aged 74 years. He was admitted to hospital in London on March 19, 1947, displaying small areas of dry gangrene on the dorsum of both feet and legs, large, deep, gangrenous areas 1½ inches in diameter in front of, and behind, the left external malleolus, and a large area of dry gangrene over the right tendo achillis. Both legs were inflamed, discolored, and edematous half-way to the knees. The patient said he had been "sloshing around" in the fluid in his boots for several days before admission. His hands were a dusky, cyanotic color. The blood sugar was normal, but the nonprotein nitrogen was 43 milligrams per cent and his sedimentation rate 76. X-ray studies of his legs showed considerable calcification of the posterior tibial artery, much more marked in the left leg. The left popliteal did not pulsate and the right pulsated only very faintly.

Beginning on March 23 he was given 300 milligrams of α tocopherol acetate per day by mouth. On the 26th he complained of "pins and needles" in his feet, and a change for the better was apparent at the upper limit of his lesions. His feet and legs were no longer edematous. His hands were no longer cyanotic. On the 28th a pulsation in the left popliteal artery was first palpable. By the 30th most of the epidermis of the legs and the dorsum of the feet had sloughed off, leaving normal pink skin underneath. At this time the more superficial gangrenous areas were rapidly healing under loosening scabs. By April 6 several of these had been cast off, and a pulsation could be detected in both posterior tibial arteries for the first time. By April 18 his right leg and foot were almost normal in appearance. On the left foot only a few of the deeper scabs remained. On April 23 his nonprotein nitrogen was 43, creatinine 1.1, and sedimentation rate 35. The corresponding values on May 2 were 43, 1.1, and 17. By April 28 both feet were healed and the patient began to walk about.

When he went into hospital amputation of both legs above the knee seemed to be the treatment of choice. Amputation is no longer necessary. He still takes 100 milligrams α tocopherol per day.

The first case of early gangrene of an extremity treated with tocopherols was a woman of 76 years of age, who was admitted to hospital December 8, 1946, for an acute diverticulitis which was promptly operated upon. Her left leg at that time showed early but discrete and superficial gangrenous areas extending as high as the knee. She was a mild diabetic under good dietary control, but with arteriosclerosis. After December 11 she was given 100 milligrams of α tocopherol per day by mouth, and soon showed great improvement in the affected leg. She was discharged from hospital on December 22, 1946 and has led an active life ever since, doing her own housework. She still takes 25 milligrams of α tocopherol per day as a prophylactic measure. There has been no recurrence of her lesions.

What would tocopherol therapy do for frostbite, "immersion foot," and similar conditions? Others with better clinical opportunities may provide the answer.

Thromboangiitis obliterans and related vascular conditions. We have thoroughly studied one verified and one dubious case.

CASE 9. Miss M. T., aged 56, single. She has never used tobacco. She began to complain of pains in her toes in 1938. The toes became dusky red, at times almost purple, and gangrene was feared as their condition became progressively worse. At that time a glass boot and other such measures in hospital over a period of 15 weeks gave temporary relief. With Buerger's exercises and careful avoidance of overexertion and heat (this has always bothered her more than cold!), she maintained an approximate *status quo* until July of 1946, although frequently during these intervening 8 years the toes were ulcerated. The greatest care was required to avoid a major foot infection and to heal these small ulcers. Once, in 1942, she almost developed dry gangrene of several toes of both feet and was forced to spend 7 weeks in bed. The toes have been numb for years, as has also been true of the feet and lower legs. When she wanted to pick up anything from the floor she could not kneel steadily because of the numb feet, but sat down in order to do so. She often awakened in the night "to see if her feet were still there." There had been considerable edema of the feet and lower legs during these years, and this was not altered appreciably by a salt-free diet.

On June 12, 1946, she was given 200 milligrams of α tocopherol acetate per day—our first case of peripheral vascular disease treated with the tocopherols. On the 15th she "could scarcely sleep for the

tingling in her arms and legs," and in the next few days purpuric areas of all sizes appeared over the trunk and extremities, accompanied by sensations of "pins and needles." She had had these purpuric manifestations at her x-ray menopause 10 years before, but not in the interim. In 10 days' time her edema decreased considerably, and her toes felt warm and had practically returned to normal color. By July 23 her feet and toes were no longer numb. She now could kneel on the floor to work or pick things up. Trauma to the toes was now felt as pain. On three or four occasions she stopped her tocopherol therapy or reduced the dose, but each time her edema and other difficulties recurred promptly. Her chiropodist could always detect changes in her dosage. Her corns began to trouble her again as soon as sensation returned to her toes, and they regained their usual color. Actually it seemed to her that the corns grew faster than before. She is now leading a very active life as a practical nurse on a difficult case.

We are well aware of the fact that the diagnosis in this case is questionable, and that to call it Raynaud's disease might be more accurate. However, the vascular relief achieved provides our reason for presenting it.

CASE 10. Mr. S. K., aged 48, a veteran of the last war. In the winter of 1944, he experienced a good deal of pain in his fingers and toes. They often felt intensely cold and would assume a dead white appearance. In June, 1945, he was sent into hospital for a stubborn ulcer on the ball of the left thumb. The palmar aspect of the right thumb then displayed extensive areas of dead white skin, and ached. His toes also were white, but not as white as the thumb. They, too, were cold to the touch and ached. His other fingers ached constantly too. When the ulcer on the thumb healed, other ulcers appeared on the tips of other fingers, some of them on the other hand. A diagnosis of Raynaud's disease was made. In October of that year the ring finger of his left hand was ulcerated at the tip. Neither detailed examination by a neurologist nor laboratory studies were helpful.

On a later hospital admission in September 1946 an x-ray examination of the hands revealed osteolytic reaction involving particularly the distal end of the distal phalanx of the third right finger and the distal phalanx of the right index finger. His feet showed similar changes involving the distal phalanx of the 2nd right and 2nd left toes, and both 4th toes. The right 5th toe showed some proliferations and cystic areas, suggesting a response to vascular occlusion. Two weeks later gangrene of the second right toe appeared, with swelling and redness of that toe and foot. Only an occasional dorsalis pedis pulsation could be felt. The right popliteal was palpable. Injection of 8 milligrams of mecholyl produced a temperature elevation of as much as 1.2 to 2.1 degrees only in the first right toe, 4th right toe, and in 1st, 3rd, 4th, and 5th left toes. In the remainder, the flushing response was less than one degree. On October 25, 1946 the right lower extremity was amputated by the Gritti-Stokes method. As the stump failed to heal, skin grafts were attempted in November, 1946, and January, 1947, but both failed to take.

The pathological report on the amputated leg revealed thickened vessels, showing in one place an old organized, canalized thrombus. There was intimal hyperplasia, a lymphocytic infiltration of the media, and a thickened adventitia. The small vessels showed either marked narrowing of the lumina or organized blood clot filling them. There was no evidence of calcification anywhere.

The condition of the other leg rapidly became worse, and, when first seen by us, on February 13, 1947, he had been sent home on 2 weeks' leave before returning to consider its amputation. The site of the unhealed skin grafts was a raw ulcer. For a fortnight he was given 300 milligrams of a tocopherol acetate per day by mouth, but not required to reduce his cigarette consumption. By the 4th day of treatment he began to feel improvement. On the 8th day increased urination developed and he no longer experienced pain in his extremities. By February 24 his phalanges were normally warm and of good color. The recalcitrant stump ulcer was now completely healed and felt normally warm. On March 14 he was able to walk on his artificial leg for 4 hours without discomfort, and his hands and remaining foot seemed nearly normal. He bought a truck and decided to begin a trucking business. However, he was unable to get tocopherol capsules for a 2 week period in April. When he next reported, on May 1 he showed a recurrence of the stump ulcer. He was promptly given tocopherols again and the ulcer healed as promptly as at first. He was working as a trucker when last heard from at the end of May.

Another typical case has had a fine result. It should be mentioned that these patients often suffer a good deal as their circulation improves. During that time they may be difficult to maintain on treatment.

Our former colleague, Dr. C. K. Stuart, has treated with tocopherols 4 patients displaying intermittent claudication, the results being excellent in 3 of them.

Our friend, Dr. George Dowd, has treated 4 such patients between the ages of 48 and 63 years. Three of the patients became asymptomatic and one was markedly improved on doses of 400 to 1100 milligrams of mixed tocopherols daily. We have had a good result in the only case we have treated ourselves.

Cerebral thrombosis. After what has been said above on the subject of thrombosis in general, little need be added here. One of the more puzzling phases of our studies has been the trivial influence the tocopherols usually

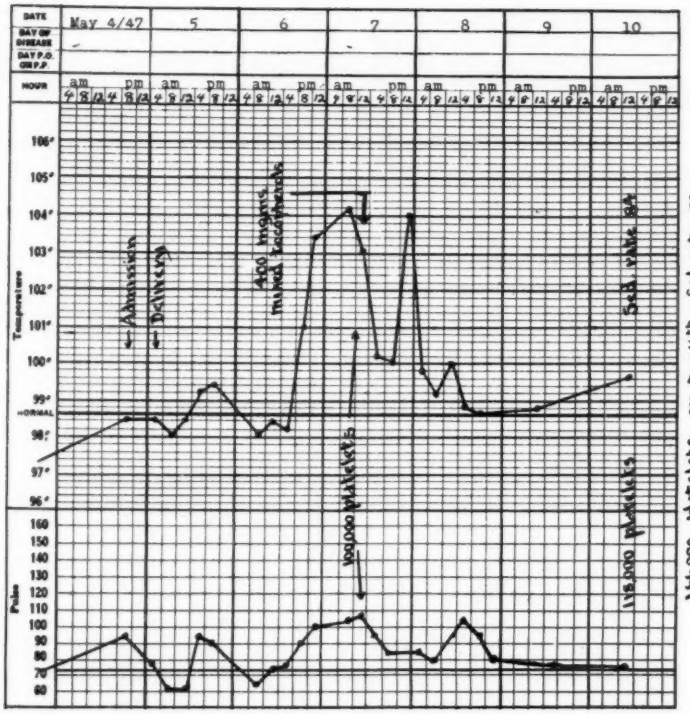

Fig. 4. Graph showing results of treatment with tocopherols only in a case of puerperal thrombophlebitis.

exert on hypertension *per se*, but the fact that in hypertensive heart disease there may be a small initial rise of both systolic and diastolic blood pressures coincident with increased cardiac tone and relief of decompensation, which is often followed by a drop as compensation occurs. The symptoms ascribable to hypertension are often relieved out of all proportion to the improvement thus achieved. This parallels the experience of Smithwick with his surgically treated hypertensives.

We have studied a score of cases of cerebral thrombosis, most of them of months' or as long as 2½ years' standing. Even in the old cases some improvement was often achieved. As would be anticipated, the patients treated most promptly did best. Generally speaking, from 10 to 75 per cent of the disability has disappeared in the group as a whole. This gain was made principally within the first 3 weeks, after which improvement went on much more slowly. It is very difficult, of course, to prove how much of what was gained was ascribable to tocopherol therapy and how much was spontaneous. Others must settle that point whose opportunities are superior to ours. We merely discuss the topic here for its suggestive value and because it is pertinent to this whole problem. But Dowd tells us he has seen definite improvement in a woman whose stroke occurred 6 years previously. If cerebral thrombosis occurs in end vessels, as medical texts have long contended, the theoretical interest of this type of case is further enhanced. One of our most interesting cases was that of an elderly lawyer who had experienced his accident in 1944, 2 years before he was first seen by us. His outstanding complaint was a central scotoma of the right eye, thought by his ophthalmologist to be on an arteriosclerotic

basis. His blurred vision dramatically improved in 3 weeks' time. Before treatment he could distinguish a person standing 6 feet away but not his features. Afterward he could differentiate all his major features.

The benefit these patients experienced may have been strictly analogous to that seen in thrombosis elsewhere. Or gliosis itself may have partially responded, as in Steinberg's cases of fibrositis and fascial contracture. Both Davison and Dowd suspect that some damaged nerve cells live in a twilight state, neither dead nor yet fully alive, until such a reparative stimulus as the tocopherols reach them and enable them to regain at least a portion of their former function.

If every hypertensive were given tocopherols would the incidence of apoplexy be reduced?

DISCUSSION

The number of patients studied in each of these groups is small, but the results are of such interest, developed so promptly, and have such an important bearing on the great problem of heart and kidney disease in general that it was felt they should be reported now.

The color photographs appended illustrate the rapidity and extent of some of the changes described.

One cannot but suspect that the surgical and medical possibilities of the field we have stumbled into will prove both fascinating and rewarding to investigators who have better opportunities than we have. Generally speaking, the tocopherols should be helpful wherever improved arteriolar circulation or better oxygen utilization in tissues is desired (10).

It would seem that when tocopherols are administered thrombosed veins relax to permit a circulation over and past the thrombus, as Pereira has clearly shown can occur with sympathetic block in like cases. The analogies of our treatment to sympathectomy are of real interest.

The need for continued treatment at high dosage levels in so many cardiovascular conditions is analogous to the situation encountered in hormone substitution therapy, for example in hypothyroidism or in diabetes. It suggests that one is either replenishing a rapid wastage of tocopherols in these particular people or combatting the continued production of some noxious bodily antagonist. Our work with the purpuras would perhaps suggest the latter and may even point to that agent as being the estrogens—another indication of the truth of our old thesis that vitamin E is antiestrogenic, whatever else it is.

The matter of dosage is fundamental in tocopherol therapy. About 200 to 300 milligrams of α tocopherol per day seems to be the average therapeutic level. The fact that it is α tocopherol that is required should be stressed. In cases of acute cerebral thrombosis we have used parenteral tocopherols with success. Patients so treated seem to react in one-half to one-third of the usual time taken when tocopherols are administered by mouth. To achieve the best results in such cases it is important to saturate the patient as early as possible in order to minimize brain cell damage adjacent to the thrombus or embolus.

Inorganic iron should not be given with the tocopherols (10).

We have even been so bold as to hazard the guess—and it can only be that in the present state of our investigations—that the tocopherols may be at least as valuable in the prophylaxis of certain vascular accidents and conditions as in their therapy. In this connection it should be pointed out that many of these conditions soon recurred after healing unless tocopherol therapy was continued at a high level permanently.

For too long, medical men have considered the vitamins to be mere food accessories, things we could either take or leave alone. But surely the time is approaching when some of them, at least, will rank as true chemotherapeutic agents, to be administered in doses comparable to those of the sulfonamides or penicillin, and for indications quite as strict and clearly understood. It may even prove that Nature thought of them as being prophylactic before we thought of them for cure, just as she left medicinal molds lying about for those to pick up who could see them under their feet.

SUMMARY

In such vascular diseases as indolent varicose ulcers of the legs, thrombophlebitis, early gangrene of the extremities, and even thromb-

angiitis obliterans, tocopherol therapy may be helpful.

Lately, several important companies in this field are labeling their tocopherols according to a new spectrophotometric assay. This means that if their products are to be used in dosage comparable to ours as high as four times as much of their product must be employed.

REFERENCES

1. Dowd, G. C. Personal communication.
2. Mason, K. E. Yale J. Biol. Med., 1942, 14: 605.
3. Idem. Personal communication.
4. Pereira, A. de S. Surgery, 1946, 19: 731.
5. Shute, E. V. Am. J. Obst. Gyn., 1938, 35: 810.
6. Idem. J. Obst. Gyn. Brit. Emp., 1942, 49: 482.
7. Idem. Urol. Cut. Rev., 1946, 50: 732.
8. Ibid., 679.
9. Shute, E. V., and Barrie, M. M. O. Am. J. Obst. Gyn., 1940, 40: 1003.
10. Shute, W. E., Shute, E. V., and Vogelsang, A. Missouri St. M. J. (in press).
11. Skelton, F. R., Shute, E. V., Waud, R. A., and Skinner, H. E. Science, 1946, June 28.
12. Stuart, C. K. Personal communication.
13. Vogelsang, A., and Shute, E. V. Nature, 1946, June 8.
14. Vogelsang, A., Shute, E. V., and Shute, W. E. Med. Rec., 1947, 160: 21.
15. Ibid., 279.

THE VISCERAL ENDOPELVIC FASCIA AND THE HYPOGASTRIC SHEATH

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EVER since John Cameron, in 1908, called attention to the significance of what he called the "perivascular sheath" as a supporting mechanism of the pelvic viscera, interest in the visceral endopelvic fascia has been on the increase and numerous attempts have been made to define, display, and describe accurately this system of structures in the pelvic cavity. So far, however, no accord has been reached in classifying and defining the component parts of the visceral endopelvic fascia. Moreover, most of the existing descriptions of this structure do not lend themselves to an easy and clear cut demonstration in the student dissecting room, nor do they fulfill the requirements of the practicing surgeon.

Compelled by the need of presenting this subject to both medical students and postgraduate students, the senior author of this article has been engaged for the last 10 years in a study of the visceral endopelvic fascia, certain phases of which will form the topic of the present contribution.

It is generally agreed upon that the fasciae of the pelvic cavity can be grossly classified under two headings, the parietal and the visceral endopelvic fascia. There exists, however, no agreement concerning the individual fascial structures which should be considered parietal and those which should be termed visceral. In order to avoid misunderstandings, it is necessary that we define the terms to be used in this article.

PARIETAL ENDOPELVIC FASCIA

Testut considered as parietal endopelvic fascia all fasciae which cover the pelvic surfaces of the muscles lining the pelvic cavity; according to this author the fasciae which cover the pelvic surfaces of the internal obturator, piriformis, levator ani, and coccygeus muscles are parietal endopelvic fascia.

Cunningham (5, 6) and, following him Cameron (2) describe the fasciae of the muscles of the pelvic floor (levator ani and coccygeus) as parts of the visceral fascia. Under the term of parietal endopelvic fascia these anatomists include only the fasciae which cover the pelvic surfaces of the muscles of the pelvic wall proper (parietes) i. e. the internal obturator and piriformis, and, peculiarly enough, also the fascia of the deep transverse perineal muscle.

Again a different grouping we find in a paper by Douglas E. Derry; this author is of the opinion that the fasciae of the coccygeus and piriformis are entirely different from the true parietal endopelvic fascia and should be considered by themselves as individual fasciae. Only the internal obturator and levator ani fasciae are parietal.

Many other views concerning this subject are encountered in the literature, too numerous to be considered here.

In the following account we have adopted essentially Testut's nomenclature; the pelvic fasciae covering the internal obturator, piriformis, levator ani, and coccygeus are parietal endopelvic fascia.

VISCERAL ENDOPELVIC FASCIA

Considering the complexity of the visceral endopelvic fascia and the lack of uniformity in the description of this structure, it is not to be wondered at that some authors became discouraged and relegated this entire fascial system to the position of an undifferentiated "packing" tissue. Outstanding among the proponents of this procedure is Douglas E. Derry who demands that the term "visceral endopelvic fascia" be dropped entirely and be replaced by the term "subserous tissue."

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Even where the latter is condensed into perivascular sheaths and fascial capsules, these structures are lacking in definition and pass gradually into the general, undifferentiated subserous tissue. We hope to show, however, that the visceral endopelvic fascia is disposed in the form of well defined, strong sheet-like structures of definite location, attachment, and function. Anybody who has read the classical work by Peham and Amreich, of the University of Vienna, entitled "*Gynaekologische Operationslehre*" will admit the existence and demonstrability of the visceral endopelvic fascia, as well as the need for accurate knowledge and description of this structure.

To mention only a few of the most important functions and uses of the visceral endopelvic fascia, attention may be called to four of them:

1. The visceral endopelvic fascia furnishes well defined capsules for the pelvic viscera. These capsules serve as points of attachment for important supporting structures composed of visceral fascia. Moreover, the capsules contain the collecting channels of the lymphatic drainage system of the pelvic viscera; surgeons are well aware that malignant growth, if it once has broken through the wall of the viscus and invaded the capsule, is prone to have formed metastases. Taking into account this fact, Jewett has recently worked out a classification of malignant growth of the bladder with respect to its operability.

2. In the form of double layered perivascular sheaths, this fascia serves as a vehicle for important vascular and nervous structures. An accurate knowledge of these sheaths enables the surgeon to locate swiftly these vessels and nerves.

3. The perivascular sheaths form partitions dividing the subperitoneal part of the pelvic cavity into fascial compartments which are completely sealed off against each other.

4. The perivascular sheaths are firmly attached to the fascial capsules and to the pelvic wall, thereby mooring the viscera securely to the walls of the pelvis. As they run in different planes and are situated at different levels, they form a framework within which the viscera are suspended.

For practical purposes as well as for the purpose of teaching, the component parts of the visceral endopelvic fascia may be classified as follows:

1. Fascial capsules varying in thickness in different regions and enclosing the pelvic viscera. Where these organs pierce the pelvic floor the capsules become continuous with the parietal endopelvic fascia. For this reason they are often described as reflections of the parietal fascia upon the walls of the pelvic viscera.

2. A horizontal band of fascia described in the anatomical nomenclature under the name of "fascia endopelvina," which arises from the parietal fascia of the levator ani along a line called the white line of the fascia endopelvina.

3. The umbilical sheath. This is a distinct fascial membrane located for the most part in the abdomen where it forms a thickened triangular band, the apex of which is attached to the umbilicus, while its two lateral sides correspond to the obliterated umbilical arteries. It contains in its midline the urachus and laterally on either side the obliterated umbilical artery. In the pelvis it becomes continuous with the capsule of the bladder and, more laterally, with the "superior hypogastric wing" to be described later on. In the abdomen it represents a part of the "visceral endogastric fascia" located between peritoneum and transversalis fascia and is especially well differentiated in newborn children. Its nature and origin have been discussed and explained by two French anatomists, Cuneo and Veau.

4. The superior hemorrhoidal sheath, a distinct perivascular sheath differentiated out from the dorsal visceral endogastric fascia around the branches of the inferior mesenteric artery. It descends down into the pelvis behind the rectum and fuses with the presacral hypogastric wing to be described in detail in this article.

5. The hypogastric sheath, an extensive and well defined double layered fascial membrane which arises over the anterior hypogastric artery and gives off a number of wings.

6. The rectovesical (rectovaginal) septum, although not of fascial origin, must be men-

tioned here because of its intimate fascial relationships. It is a well defined membrane interposed between the rectum dorsally and the bladder and prostate gland (vagina in the female) ventrally.

7. And finally the loose areolar tissue; this is present in relatively small amounts in the spaces between the viscera and fascial sheets. It is found also sandwiched in between the two fascial layers of which the perivascular sheaths are made up, containing embedded in it the vessels, nerves, and other structures.

The present account is intended especially to call attention to, and present a description of, the hypogastric sheath and its components. In addition, the rectogenital septum which has been described in detail in another article, and its fascial relations, as well as the "fascia endopelvina" will be referred to.

HISTORY OF THE HYPOGASTRIC SHEATH

Since the hypogastric sheath will form the major topic of this article, it is appropriate that we discuss briefly the history of our knowledge of this structure.

According to Testut-Latarjet's "*Traité d'anatomie humaine*" this structure was first described by Jarjavet, Abernethy, and Farabeuf, under the name of "*Gaine hypogastrique.*" These authors, however, as well as Testut did not see anything else of this structure but a packing tissue around the anterior division of the hypogastric artery, filling in a space dorsal to the peritoneum, the "pelvirectal space."

Cameron (2, 3), a Scottish anatomist, in 1908 was the first one who described the hypogastric sheath, under the name of perivascular sheath, as a well defined structural entity and recognized its importance as a mechanism of support and fixation for the pelvic viscera. To give expression to this specific function he suggested for it the name of "fascial mesentery" of the pelvis. While his description was incomplete and did not include all the components of the hypogastric sheath, his anatomical studies must be considered as the starting point of our knowledge of this structure.

In 1930, Peham and Amreich made the hypogastric sheath the basis of their description of the visceral endopelvic fascia. Aside from the fact that they did not include all the components in their description, they used an unfortunate nomenclature, homologizing certain fascial elements with one another, which in reality are of entirely different nature and origin. We shall have occasion to refer to their views later on in the course of our discussion.

MATERIAL

The following description of the visceral endopelvic fascia rests mainly on the dissection of the embalmed pelvis of a colored female, 29 years of age and recorded as Series 4794a, 1946. While the dissection was in progress, its individual steps were recorded by a number of illustrations. Eleven of these are reproduced in this article, numbered successively as Figures 1 to 11. Several additional illustrations taken from dissections of other cadavers and supplementary to the illustrations of the pelvis 4794a, 1946, are denoted by a small letter placed after the figure number (as for instance 6a).

Special features of the specimen. The pelvis was divided into two halves by a median sagittal saw cut. The left half was left intact with the peritoneum undisturbed. It served for comparison of important landmarks, while the right half of the pelvis was in progress of dissection.

In Figure 1, the left half of the pelvis, with the peritoneum in place, is shown. In the dissecting room we rarely ever see a normal female pelvis, a very great handicap in the study of female pelvic anatomy. This woman, however, had no other gross pathology but that her tubes were closed on both sides. But she possessed a very unusual anomaly; the ligament of Mackenrodt was completely separate from the flaccid part of the ligamentum latum. A wide gap existed between them; only their uterine ends were connected by a narrow peritoneal fold.

On the dorsolateral wall of the pelvis there was seen, in this specimen, a peritoneal fold (recorded as ridge No. 8), about 1 inch wide, passing caudally and ventrally. Dorsally it had a sharp, falciform boundary, its ventral border was round. The ventral half of its

width was seen passing forward, under the broad ligament, toward the bladder; it contained, as we will see later on, the ureter and inferior vesical vessels. Its dorsal half, at a point quite a distance ventral to the ischial spine, made a turn medially and became attached to the uterus. Judging from the contents of this fold, it represented as far as sex is concerned, a nonspecific structure. Only the short portion, from the point where part of it turned medially toward the uterus, proved to be specifically female, representing the cardinal ligament of Mackenrodt.

RECTOVAGINAL SEPTUM

The pouch of Douglas extended exceptionally far caudal in this specimen. The bottom of the pouch was only 30 millimeters (a little more than 1 inch) cranial to the floor of the pelvis. Nevertheless, as Figure 1 shows, a distinct rectovaginal septum was present. It is of interest to notice that the septum was attached to the dorsal wall of the vagina; from the rectum it was separated by a quantity of loose connective tissue. When the uterus and with it the vagina were pulled forward, the septum followed the vagina. This condition corresponds to the situation as it exists in the male; there the septum is always attached to the prostate gland. If a finger is introduced into the rectovaginal interval through a transverse perineal incision, the operator may feel reasonably certain, that the rectovaginal septum will be in front of his finger, separating the finger from the vagina, while dorsally the finger will be in direct contact with the rectum.

In Figure 2 a dissection is illustrated which was made to display some of the relations of the rectovaginal septum in greater detail. Cranially the rectovaginal septum is attached to the peritoneum of the pouch of Douglas; its caudal end could be followed all the way down to the pelvic floor. While in many adult specimens the line of fusion is marked at the bottom of the pouch by a white line and some strong peritoneal cords bridging over this white line (as will be described in detail in another article), the inner surface of the peritoneum of the rectovaginal pouch was entirely smooth in this specimen. The cranial end of the septum had remained separated into two limbs representing its original two layers; each limb was continuous with the peritoneum of the corresponding wall of the pouch, and the line of fusion, instead of being bridged over by separate cord-like binders, had been grown over by a continuous layer of peritoneum.

Special pains were taken to check the statement made by Curtis, Anson, and Beaton in a recent article (7), according to which the tissue separating the vagina from the rectum is composed of the fascial capsules of these two viscera and some loose cellular tissue intervening between them. It was found that the rectovaginal septum is a structure additional to and well differentiated from, the capsules of both the rectum and the vagina.

Another important relationship is shown in Figure 2. The capsule of the genital viscus is attached by its cranial end to the peritoneum; beyond this point, over the body and fundus of the uterus, a fascial capsule could not be demonstrated as a structure independent of the peritoneum. This condition is the rule and is well known. Exactly the same relationship holds true for the ventral portion of the fascial capsule of the rectum, as is shown in this dissection. We have found, however, subjects in which the ventral rectal capsule extended all the way up to the colon.

HYPOGASTRIC SHEATH AND MAIN ANCHORAGE OF PELVIC VISCERA

In Figure 3 the right pelvis is shown after most of the peritoneum had been removed. The bladder was pulled medially, permitting a view into the space of Retzius; both its ventral and lateral compartments can be seen.

The two structures, representing the main anchorage of the pelvic viscera, are displayed. They are (1) the root of the hypogastric sheath, (2) the fascia endopelvina.

The fascia endopelvina forms the floor of the space of Retzius, the root of the hypogastric sheath seals off the space of Retzius dorsally. The fascia endopelvina occupies a nearly horizontal plane, while the root of the hypogastric sheath lies in a nearly vertical and almost frontal plane; if a hand is introduced into the space of Retzius and pushed

dorsally along the lateral surface of the bladder, it slides at first along the fascia endopelvina, as far back as the ischial spine. At that point its further dorsal progress is blocked by the root of the hypogastric sheath. Further movement is then possible only in a direction cranially and ventrally, along the hypogastric root, which is directly continuous with the fascia endopelvina, but forms with it an angle of approximately 90 degrees. From this account it will be seen that the main line of attachment of the pelvic viscera imitates in direction the shape of the pelvic viscera themselves; most caudally their direction is nearly horizontal; after making a bend of nearly 90 degrees, they are running in a vertical direction.

Peham and Amreich recognized this correlation between the direction of the pelvic viscera and the direction of their main anchorage line. They call the fascia endopelvina the "horizontal groundplate," the hypogastric root the "frontal groundplate." This nomenclature, however, fails to consider that these two elements are of entirely different nature. The hypogastric root and its derivatives are essentially perivascular sheaths. The fascia endopelvina is of the nature of a true ligament, partly aponeurotic in texture, and is in addition a secondary formation characteristic of man but missing in lower forms.

Figure 3 permits a gross orientation of the components of the hypogastric sheath. The hypogastric root (fascia hypogastrica dorsalis) is attached to the wall of the pelvis along a line corresponding approximately to the dorsal border of the superior ischial ramus and ends caudally at the spine of the ischium which can be palpated by a finger thrust into the lateral compartment of the space of Retzius. It arises from the parietal endopelvic fascia over the anterior division of the hypogastric vessels and over the ureter (Fig. 3). Like all its derivatives it is composed of two fairly stout membranous layers between which the ureter, the vascular and nervous structures are sandwiched in, embedded in some loose areolar tissue. In Figure 3 only the lateral layer of the hypogastric root is visible; the medial layer will soon be demonstrated.

The hypogastric root passes forward, toward the bladder and is divided by this organ into two wings, a superior hypogastric wing (fascia hypogastrica superior) and an inferior wing (fascia hypogastrica inferior). Dorsally and and medially it gives off an extensive double layered membrane, the presacral hypogastric wing (fascia hypogastrica presacralis).

THE HYPOGASTRIC WINGS

With the aid of Figure 3 we will now discuss the hypogastric wings slightly more in detail.

a. *Presacral wing.* The presacral wing extends from its origin all the way across the pelvic cavity, in front of the sacrum and in front of the parietal fascia covering the piriformis and coccygeus muscles, meeting in the median line its fellow from the opposite side. The superior hemorrhoidal vessels, enclosed in a special sheath, the superior hemorrhoidal sheath, are incorporated into the presacral wing. Where it hits the rectum, it splits into its dorsal and ventral layers, embracing the rectum and furnishing for it its fascial capsule.

Cranially the presacral wing is very wide. Further caudally, as it follows the curvature of the rectum, it narrows down and passes forward together with the rectum, forming a fascial wing of the rectum, which attaches itself laterally to the fascia endopelvina.

Between the presacral wing and the parietal fascia a space is formed, the retrorectal space. Laterally this space is sealed off against the lateral compartment of the space of Retzius by the hypogastric root. Lowsley and Kirwin (p. 947, vol. 2, 2d ed.) state that the space of Retzius extends "as far back as the rectum." We feel it of importance to emphasize that a hand carried back in the lateral compartment of the space of Retzius is stopped on its way to the rectum by the root of the hypogastric sheath which forms the dorsal wall of the space of Retzius and represents a partition between the space of Retzius and the retrorectal space. We will see presently how communication between these two fascial compartments can be created.

b. *Superior hypogastric wing.* As seen in Figure 3 the superior hypogastric wing follows the lateral margin of the superior surface of

the bladder. There it splits open into its two layers one of which becomes continuous with the fascial capsule on the superior, the other with the fascial capsule on the inferolateral surface of the bladder. Ventrally it is continuous with the umbilical sheath and that part of visceral endogastric fascia which lies between the peritoneum and the transversalis fascia. Laterally it sweeps across the lateral compartment of the space of Retzius, forming the roof of this fascial space and passing up on the lateral pelvic wall, to become continuous with the visceral endogastric fascia in the iliac fossa. In order to be able to pull the bladder medially, we had to cut through the superior wing; its medial (pelvic flap) contains the umbilical artery and, as we will see later on in a medial view (Fig. 6), the superior vesical branches of this artery. The lateral flap of the superior hypogastric wing passes over the brim of the pelvis, forms a fascial sheath around the iliac vessels and is continued into the iliac portion of the visceral endogastric fascia (Fig. 3).

Peham and Amreich describe (p. 197) this superior hypogastric wing under the general heading of "*Das lockere Bindegewebe*," employing for it the name of "*Lamina ligamenti umbilicalis*." In this interpretation of the lateral wing they follow evidently those who consider the entire visceral fascia of the abdominal cavity as an undifferentiated layer of extraperitoneal fat, subserous cellular tissue, etc. We possess a dissection which we made in 1941 and in which the capsule of the bladder has been dissected as a continuous sheet all around the organ, with the two superior hypogastric wings attached and their continuity with the visceral endogastric fascia preserved. In this specimen these wings have been demonstrated as stout, well differentiated membranes which are able to resist considerable pull, an observation which holds true for the entire hypogastric sheath. Upon studying this fascia one understands why some of the older anatomists, such as for instance Hesselbach clung to the description of the peritoneum as a "duplicature" composed of an internal and an external peritoneum, even after Ruysch and, later on, Douglas, in whose book the history of this subject may be found discussed, had separated the outer layer under the name of "membrana cellulosa" (Ruysch) or "membrana vesiculosa" (Douglas) from the true peritoneum.

c. *The inferior hypogastric wing.* The inferior hypogastric wing is of special importance; it represents one of the major mechanisms of fixation for the bladder and contains the ureter and the inferior vesical vessels. In cystectomy this wing must be cut through in its entire length. The urologists are therefore especially mindful of this wing; it is the same structure which Hugh Jewett calls the inferolateral ligament of the bladder.

In Figure 3 we see its lateral surface (its medial side will be shown later on). It comes down from the root of the hypogastric sheath; medially it is attached to the dorsolateral margin of the bladder, laterally to the fascia endopelvina.

Shining through the lateral layer of this wing we always see the plexus of Santorini and several stout venous drainage channels of the plexus, the inferior vesical veins.

It has already been mentioned that the most caudal narrow portion of the presacral wing is attached laterally to the fascia endopelvina. And now we have learned that the inferior hypogastric wing is likewise attached to the fascia endopelvina. Presently we will see that two other leaf-like structures, the fascial wing of the vagina and the rectovaginal septum, are attached to the medial edge of the fascia endopelvina.

THE FASCIA ENDOPELVINA

As mentioned the fascia endopelvina is the structure which forms the horizontal floor of the space of Retzius. Under standard conditions it arises from the levator ani fascia along the "white line of the fascia endopelvina," a line which passes from a point lateral to the inferodorsal end of the symphysis pubis to the ischial spine. The manner of origin and condition of its special differentiations is subject to very great variations which to discuss is not the object of this article. Suffice it to say that the line seen in this specimen is (Fig. 3) not the white line of the fascia endopelvina, but the arcus tendineus of the levator ani,

a second line which ordinarily runs cranial to the white line of the fascia endopelvina. In this case this fascia had no special white line; it came off the levator ani fascia a little caudal to the arcus tendineus.

The most ventral part of this fascia was, in this subject, differentiated into three stout ligaments; or expressed more correctly it formed a fascial investment for these three ligaments. Most medially the fascia had been cut away to expose the medial pubovesical ligament and the lateral pubovesical ligament. The former we have found so far in every subject examined, female as well as male; it contained wherever we looked for them, reddish muscle fiber bundles which radiate out into the superficial layer of the detrusor vesicae intermingling with its fiber bundles. The lateral pubovesical ligament is found more rarely.

Further dorsal the fascia endopelvina appears as a tough band which is of white color and ends dorsally into a sharp crescentic margin, the lateral true ligament of the bladder. This term is rather incorrect, since in reality, this ligament is connected to the bladder only by the intermediation of the inferior hypogastric wing and since it serves also and in exactly the same manner for the attachment of vagina and rectum. However, it seems unnecessary to change this generally employed nomenclature. This ligament is considerably variable; we have found specimens where several crescentic margins were interposed in its course. It can be very short or, as in the present case, very long; it measured in this subject fully 5.9 centimeters (over 2 inches).

Dorsal to the crescentic margin of the ligament the fascia endopelvina comes off at a lower level and cannot be seen in this illustration. It was necessary to tilt the upper end of the pelvis forward to expose the fascia endopelvina to full view; such a view is illustrated in Figure 4.

THE PORTIO CARDINALIS OF THE LEVATOR ANI

After the fascia endopelvina has been incised, the aponeurotic fibers of the lateral true ligament of the bladder were exposed. The structure which interests us, however, is the one located dorsal to this ligament. Underneath the visceral fascia the fleshy bundles of the iliococcygeus, exactly as in the male, are seen as they pass, in steep course, caudally and medially, covered in this situation by a rather thin parietal fascia. But immediately dorsal to the lateral true ligament of the bladder, some special levator ani fibers, mixed with aponeurotic fibers, leave the major portion of the muscle and pass into the inferior hypogastric wing (Fig. 4). Because of their functional significance for the cardinal ligament, we have called these fibers the portio cardinalis of the levator ani. In our specimen, this portion was approximately three-quarters of an inch long. We want to emphasize the location of these fibers; they correspond in location not to the ischial spine, but are situated about an inch and a quarter ventral to the spine.

In Figure 5 a window was cut out of the inferior hypogastric wing to expose its contents. Also the superior wing was cut away from the bladder; through the gap created thus, the cervix is exposed to view. The ureter and the inferior vesical vessels are seen running forward to the bladder. But just opposite the place where the special levator ani fibers are located, the uterine vessels make a sharp turn medially to enter the ligamentum cardinale. We will come back to this relation between the root of the cardinal ligament and the cardinal portion of the levator ani, when we will inspect the inferior wing from its medial side.

APPROACH TO THE RECTUM FROM THE SPACE OF RETZIUS

At the caudal end of the root of the hypogastric sheath there is located an arch-like toughening of the fascia (Fig. 5); in exploring the lateral compartment of the space of Retzius this arch can easily be felt with the fingers. Frequently in the embalmed cadaver, a hard cord-like structure may be felt through the fascial covering of the arch, the nature of which will be mentioned later. Laterally this arch is attached to the ischial spine which can also be palpated with the fingers. From this origin this arch passes forward and me-

dially to be continued into the inferior wing of the hypogastric sheath, as illustrated in Figure 5. In our specimen another arch-like structure pointing dorsally with its concavity, was present; it marked the dorsal end of the fascia endopelvina. The space between these two arches was bridged over by fascia (Fig. 5) which indicates the transition of the hypogastric root into the fascia endopelvina. In many instances this fascial bridge is formed by fascia which is so thin that a finger may be thrust through it; in other cadavers it is merely composed of some loose, orange-colored fat.

We made an incision through this fascia and introduced a piece of rubber-tubing through the hole created thus. Pushing the rubber tubing dorsally we observed that it appeared in the retrorectal space, between the presacral wing and the parietal fascia. In this subject the rectum was situated very asymmetrically, its largest part lying to the left of the median plane. In most subjects the rubber-tubing would have come out dorsal to the rectum. A second piece of rubber tubing was introduced through the incision in the fascia endopelvina, just dorsal to the cardinal portion of the levator ani; without any resistance it could be pushed into the retrorectal space. As this illustration shows an incision through the floor of the lateral compartment of the space of Retzius, extending from the dorsal end of the cardinal portion of the levator ani to the ischial spine will create a hole large enough to introduce a finger. The finger can be pushed past the line of attachment of the inferior hypogastric wing to the fascia endopelvina, into the retrorectal space and the dorsal circumference of the rectal wall can be palpated.

As mentioned previously, the space of Retzius is sealed off against the retrorectal space, by the hypogastric root; we have now demonstrated that it is partitioned off against the retrorectal space also by the floor of the space of Retzius. We have demonstrated furthermore, how we can create access from the space of Retzius to the dorsal side of the rectum. This approach to the rectum can be created without the necessity of opening the peritoneal sac.

THE INFERIOR VESICAL ARCH

In order to analyze further the inferior vesical arch, a window was cut through the lateral fascial layer of the hypogastric root; through it we see the main inferior vesical vein as it passes from the bladder, through the inferior hypogastric wing and inferior vesical arch, into the hypogastric root.

So far, we have found this arch in every subject in which we looked for it. It is by no means a specifically female feature, but occurs alike in both sexes. Invariably we found a large inferior vesical venous channel passing immediately through this arch, and frequently also an inferior vesical artery; in Figure 5 this artery is exposed in the window of the inferior wing; it could be traced through the fascia from the arch into the inferior wing as illustrated in Figure 5.

We believe that great emphasis should be placed upon this inferior vesical arch. Because of the readiness with which it can be palpated without opening the peritoneal sac, it serves as an important and easy to locate landmark; just caudal to it the floor of the lateral compartment of the space of Retzius can be incised without injury to vessels or any other important structures, and access can be gained to the rectum.

And furthermore the inferior vesical arch is closely related to an anatomical mechanism which has the function of mooring the bladder to the pelvic wall. The arch is located just cranial to the place where the upper margin of the coccygeus muscle runs transversely across the space between the ischial spine laterally and the sacrum medially.

In our specimen this margin was aponeurotic and of the nature of a sharp, falciform edge. It was the cause of the existence of the arch at the dorsal end of the fascia endopelvina (Fig. 5). Behind this upper edge of the coccygeus muscle the terminal branches of the ventral division of the hypogastric vessels, the inferior gluteal and internal pudendal vessels, are passing through the infrapiriform space from the pelvic cavity into the gluteal region. Owing to this anatomical arrangement the hypogastric vessels where they give origin to their visceral branches are held firmly against the piriformis muscle by

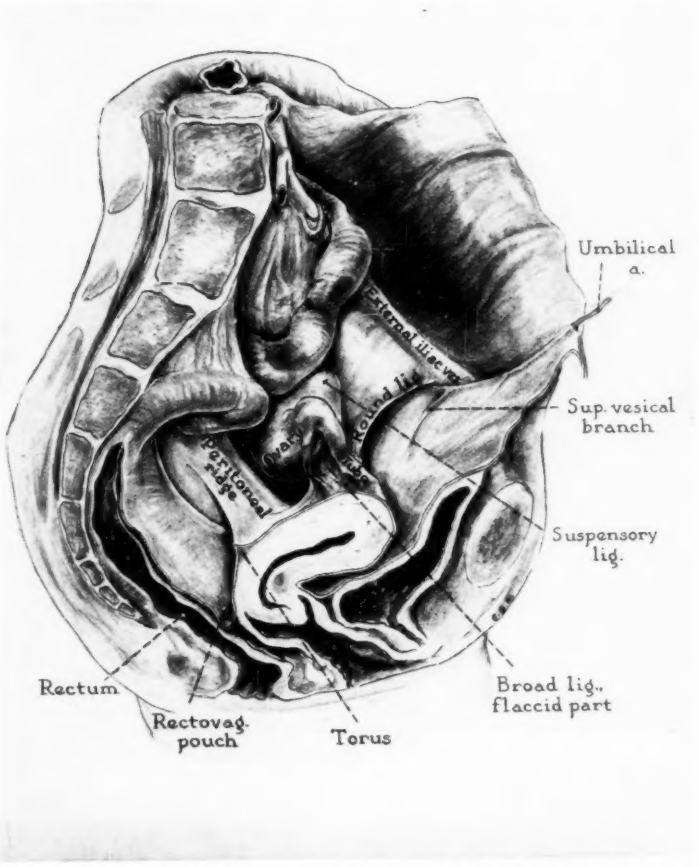

Fig. 1. Left half of pelvis of colored female (479 42a, 1946), 29 years of age. Peritoneum left in place.

the upper arched margin of the coccygeus muscle and are thus supplying an effective mechanism of counteracting any force which pulls on them in a ventral direction. The bladder has a tendency of being displaced forward and downward; by the intermediation of the inferior hypogastric wing which arises just at the point of the inferior vesical arch and contains the inferior vesical vessels which in many cases are joined to the hypogastric vessels just cranial to the inferior vesical arch, the bladder is securely moored to the pelvic wall.

It appears, then, that the inferior vesical arch is specifically associated with the bladder, and that the ischial spine marks the place of a specific mechanism for the anchorage of the bladder, both in the female and in the male.

THE CARDINAL LIGAMENT (OF MACKENRODT)

Peham and Amreich consider the ischial spine as the place of origin of the cardinal ligament; and the anatomical arrangement of the vessels, which we have just discussed and which we consider specifically related to the fixation of the bladder, is in the opinion of these authors a specifically female feature, a mechanism of anchoring the uterus to the pelvic wall. A study of the male pelvis where

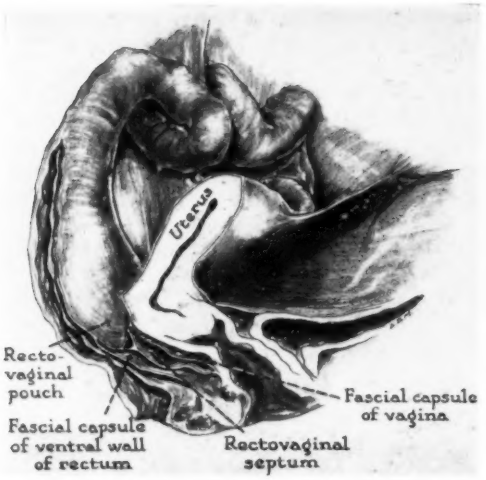

Fig. 2. Part of left half of pelvis shown in Figure 1, picturing rectovaginal septum and its relationship to capsules of rectum and vagina. Peritoneum left in place.

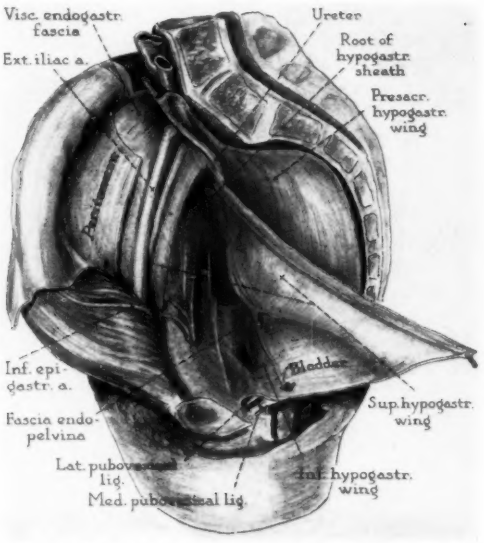

Fig. 3. Right half of pelvis of female 479 42a, 1946. Peritoneum largely stripped away. Superior hypogastric wing cut away from its lateral attachment. Bladder pulled medially and forward. Lateral compartment of space of Retzius exposed to view.

exactly the same arrangement exists, as well as a consideration of the direction in which the uterus pulls, would make it difficult to follow Peham and Amreich in their interpretation. The pull which the uterus exerts upon the pelvic wall via the cardinal ligament, is not directed forward, but medially and downward.

In order to clarify this problem we must now turn to a study of the cardinal ligament which in this specimen, as we have seen, was completely separated from the broad ligament and could therefore be studied individually. For this purpose we will inspect a medial dissection of the same half of the pelvis, which we have studied so far from the lateral side. This dissection is illustrated in Figure 6.

The peritoneum had been largely removed. The superior surface of the bladder, with its fascial capsule intact, is seen. The superior hypogastric wing, cut through along the pelvic brim, is now viewed from its medial and cranial aspect; the umbilical artery and one of its superior vesical branches are shining through the fascial layer. At the apex of the bladder the transition of the superior hypogastric wing into the umbilical sheath and the continuity of both of these fascial structures with the fascial capsule of the bladder are visible. The uterus and ovary have been reflected medially. The round ligament was running across the medial surface of the superior hypogastric wing; it was separated from it to permit the medial reflection of the body of the uterus. Also the suspensory ligament of the ovary with the ovarian vessels was running across the medial surface of the superior hypogastric wing; it had to be cut through in order that the ovary might be reflected medially. In the male the vas deferens takes a course similar to that of the round ligament of the female. When seen in the pelvis, after the peritoneum has been stripped off, the vas deferens appears to take an almost horizontal course from a point where it crosses the brim of the pelvis toward the ischial spine. As shown in Figure 6a, it is situated in this course upon the medial and superior surface of the superior hypogastric wing; to this it is attached in some cases, as shown in Figure 6b, an illustration made for us by Professor Carl D. Clarke from the dissection of a white male, by a narrow fascial "mesentery" upon which it can be freely moved against the superior

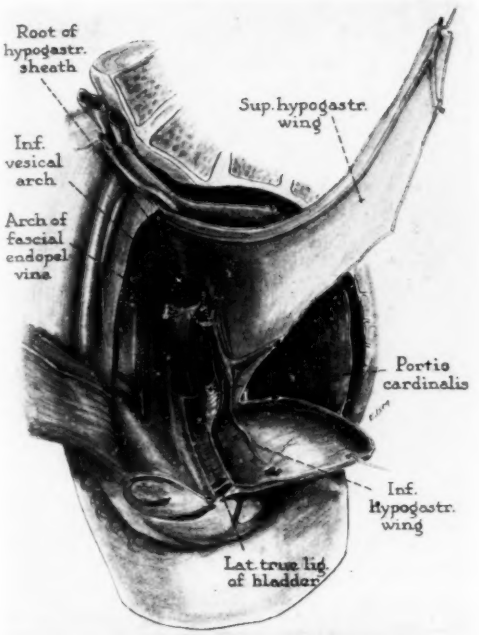

Fig. 4. Same dissection as in Figure 3, but promontory tilted slightly forward, to permit full view upon floor and dorsal wall of lateral compartment of space of Retzius. Superior hypogastric wing cut away from lateral margin of bladder. Fascia endopelvina incised as far dorsally as ischial spine and arch of fascia endopelvina, to expose lateral true ligament of bladder and the portio cardinalis of levator ani.

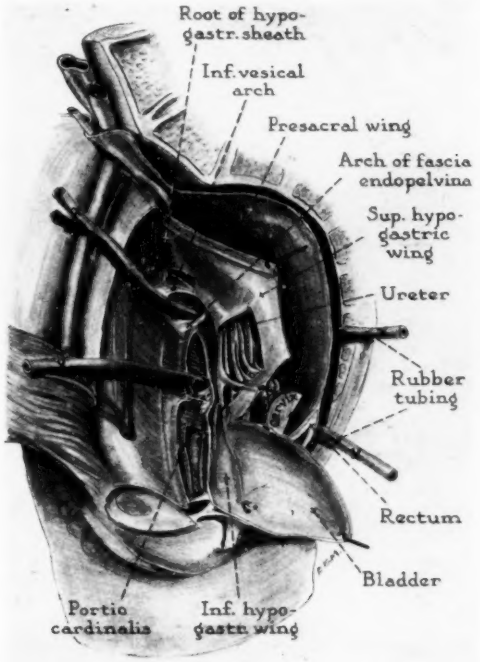

Fig. 5. Same dissection as in Figures 3 and 4; windows have now been cut into the lateral layer of the inferior vesical arch and inferior hypogastric wing. Through the former the inferior vesical vein is visible. In the latter the ureter, the inferior vesical vessels and the uterine vessels are exposed to view; also it is seen that the vesical structures pass forward toward the bladder whereas the uterine vessels make an abrupt medial turn toward the uterus. The place where the uterine vessels turn medially represents the lateral root of Mackenrodt's ligament and lies at the same transverse level as the portio cardinalis of the levator ani. Body and fundus of uterus have been cut away. The fascia closing the space between the inferior vesical arch and the arch of the fascia endopelvina was incised and a piece of rubber tubing (x) was pushed through the incision. A similar piece of rubber tubing (y) was pushed through the floor of the lateral compartment of the space of Retzius, just dorsal to the portio cardinalis. Both tubes appeared in the retrorectal space, dorsal to the presacral wing and the rectum.

hypogastric wing. This relationship is of importance; it means in the first place that the vas deferens descends nowhere to the level of the pelvic floor, and secondly, that it is strictly separated, by the two fascial layers of the superior hypogastric wing and the structures enclosed between them, from the space of the lateral compartment of the space of Retzius. In a similar manner the round ligament and the ovarian vessels of the female are separated from this space by the superior hypogastric wing.

By thrusting the hand into the lateral compartment of the space of Retzius and against the lateral side of the hypogastric root, it was ascertained that the ridge No. 8 which we saw in Figure 1, was only the medial side of the root of the hypogastric sheath. The medial fascial layer of the hypogastric root was now carefully removed and cut away; its cut edges are visible and the lateral layer which was seen upon inspection of the space of Retzius, is now seen from the medial side in the spaces between the vessels.

The contents of the hypogastric root are clearly seen; they consist of the anterior di-

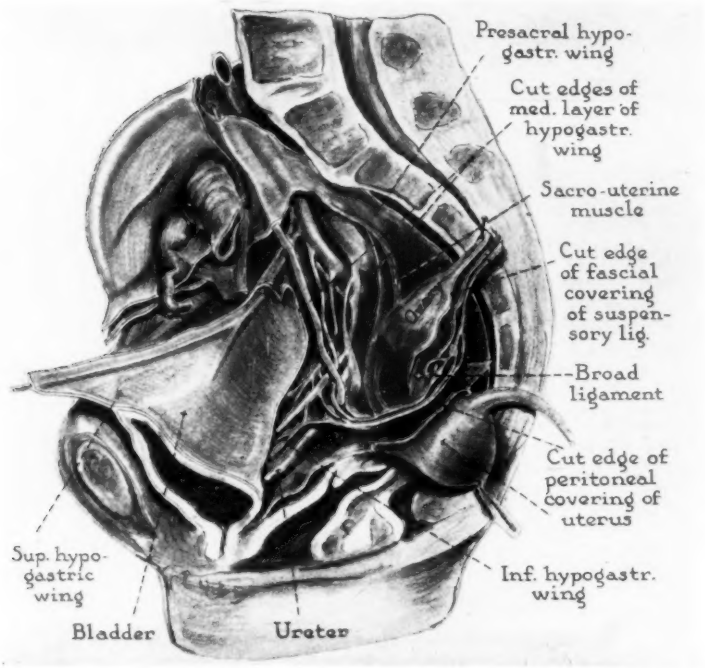

Fig. 6. Same pelvis as shown in Figures 3 to 5, but showing dissection from medial aspect. Both the suspensory ligament of the ovary and the round ligament have been cut in order to permit medial reflection of uterus and ovary. The genital stump of the suspensory ligament is seen attached to the ovary, the genital stump of round ligament was left with the uterus. The superior hypogastric wing is now seen from the cranial and medial side, with the umbilical artery and one of its superior vesical branches in it. The medial layer of fascia of the hypogastric root and of the inferior hypogastric wing has been removed. In the former the ureter and the hypogastric vessels with their visceral branches are seen passing caudally; in the latter the ureter and vesical vessels are passing forward. The uterine vessels are seen turning medially to enter the Mackenrodt portion of the broad ligament. The flaccid portion of this ligament is seen as it connects the ovary with the uterus; it contains the anastomosis between uterine and ovarian vessels.

visions of the hypogastric vessels, of the visceral branches of these vessels, and of the ureter. The uterine and inferior vesical arteries arise separately. The rectouterine muscle, corresponding to the sharp dorsal margin of ridge No. 8 in Figure 1 is seen as it had been dissected out of the fascia. All these structures pass nearly vertically, from cranial to caudal. At a point corresponding to the place where, upon inspection of the space of Retzius, we had seen the inferior vesical arch, the vascular structures begin to take a forward course, entering the inferior hypogastric wing, the medial layer of which has been removed in order to expose its contents. In this wing all the vesical branches and the ureter pass forward, toward the bladder. Exactly the same situation is found in the male; everyone of the structures so far discussed, has its exact counterpart in the male pelvis. There is, therefore, no good reason to include anyone of these parts under the name of Mackenrodt's ligament. In particular it seems incorrect to count the entire hypogastric root, as Curtis, Anson, and Beaton (7) did, as part of Mackenrodt's ligament, or to count the part of the inferior hypogastric wing, immediately ventral to the ischial spine, as part of Macken-

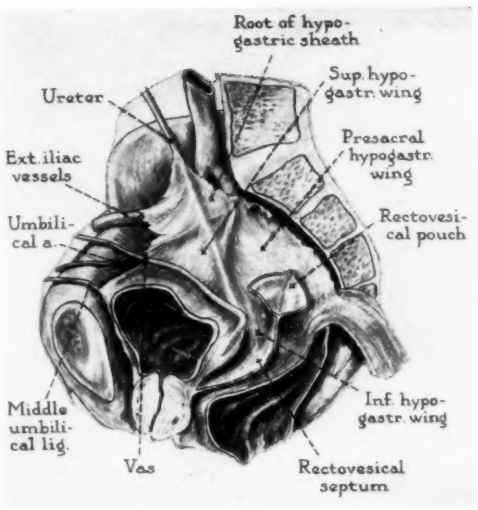

Fig. 6a. Right half of pelvis of a white male (479 41a, 1945), aged 69 years. Peritoneum removed everywhere except for the rectovesical pouch and septum. The hypogastric sheath is seen in its entire extent. The vas deferens passes across the superomedial surface of the superior hypogastric wing and is thus excluded from the space of Retzius.

Fig. 6b. Right half of pelvis of a white male of unknown age (479 40, 1945). Peritoneum removed (except for the peritoneum of rectovesical pouch and septum) and elements of hypogastric sheath exposed to view. The vas deferens is seen running across superomedial surface of superior hypogastric wing, attached to it by a "fascial mesentery."

rodt's ligament, as Peham and Amreich did. The beginning or root of Mackenrodt's ligament as a specifically female element, is clearly marked; it lies at the point where the uterine vessels are making a sharp medial turn, branching away from the inferior hypogastric wing nearly at a right angle. Its distance ventral from the inferior vesical arch and ischial spine, measured in the sagittal plane, was 33 millimeters (more than 1 inch).

It becomes immediately obvious that the ischial spine and the relations existing there between the vessels and the coccygeus muscle, as discussed previously, can serve only remotely, by the intermediation of the inferior hypogastric wing, as a means of uterine fixation.

In looking for structures which are specifically developed to counteract the medial pull of the cardinal ligament, we recollect now the portio cardinalis of the levator ani (Fig. 4), a series of fleshy and aponeurotic bundles inserted into the inferior hypogastric wing at exactly the place where the uterine vessels are branching off into the cardinal ligament. We observed that pulling on the cardinal ligament in a medial direction, puts these fibers on tension. It is obvious that the specific function of the cardinal portion of the levator ani is that of fixing the root of the cardinal ligament to the pelvic floor. This interpretation agrees well with the fact that in the male the cardinal portion of the levator ani is absent.

In this connection it is interesting to speculate on the effects which the peculiar anatomical relation existing between ureter and uterine vessels, at the point where these vessels turn medially, may have upon the ureter. Throughout the largest part of their course the uterine vessels are running dorsal to the ureter. At the point where these vessels turn medially, they pass first to the lateral side of the ureter and then hook around its ventral aspect. It is evident that by this arrangement the ureter being encased firmly between the two layers of the inferior hypogastric wing

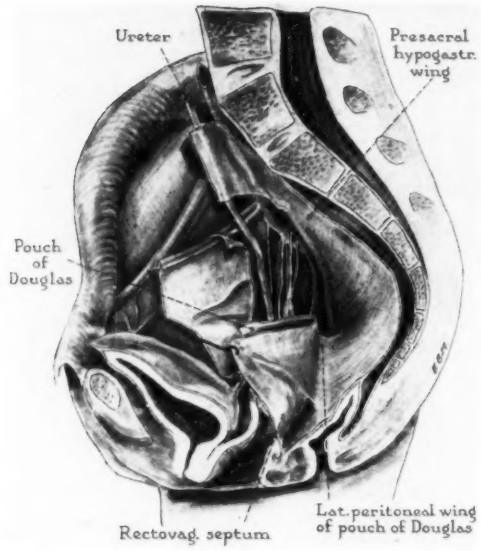

Fig. 7. Next step in the dissection shown in Figure 6. Rectovaginal septum dissected away from rectum. Septum and rectovaginal pouch (of Douglas) pulled forward to permit a view into the prerectal space. Also the lateral peritoneal wing of the pouch and its attachments are visible.

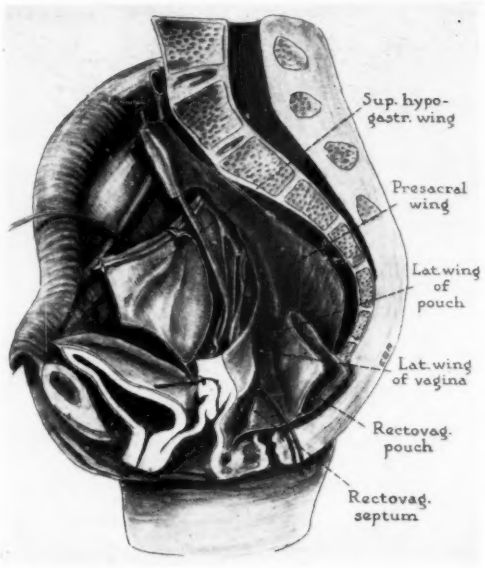

Fig. 8. Same dissection as in Figure 7, but rectovaginal septum has been dissected away from wall of vagina. Septum and rectovaginal pouch pulled dorsally to permit a view into retrovaginal space. Also the ventral surface of lateral peritoneal wing of pouch and the dorsal surface of the lateral fascial wing of the vagina are visible. A ureteral catheter was introduced into an incision made in the lateral wing of the vagina; it could be pushed into the lateral compartment of the space of Retzius.

is made a counterpoise against the medial and downward drag exerted by the uterus upon the cardinal ligament, thereby aiding in some measure the other structures which serve as mechanical supports of the uterus. From these anatomical and mechanical relationships it would appear probable that in the female certain conditions may arise where the uterine vessels are enabled to cause a strangulation of the ureters, resulting in hydroureter and hydronephrosis. If the parts of the levator ani muscle and the structures of the urogenital diaphragm surrounding the introitus, both of which are important components of the entire supporting system of the uterus, should fail owing to damages received for instance during childbirth and the cardinal ligament alone is no longer able to prevent a caudal dislocation of the uterus, it is conceivable that the drag of the uterine artery may become so great as to produce a strangulation of the ureters which owing to their fixation within the inferior hypogastric wing would be unable to give way and thus relieve the pressure exerted upon them by the uterine vessels. Ever since Tandler and Halban, in 1907 (quoted by Brettauer and Rubin) published their studies on prolapse of the uterus, it is known that hydroureter is a condition which is conspicuously often associated with prolapse of the uterus. These findings were confirmed later on (in 1923) by Brettauer and Rubin; moreover these authors suggested actually that the cause of the frequent association between these two disorders is the strangulation of the uterus by the drag of the uterine vessels. Unfortunately nobody seems to have furnished actual evidence in favor of this theory by dissection of suitable cases. Everett in his book on female urology, quotes Brettauer and Rubin, but does not adduce any literature actually confirming the suggestion made by these authors. Should this theory, however, prove correct, it would furnish addi-

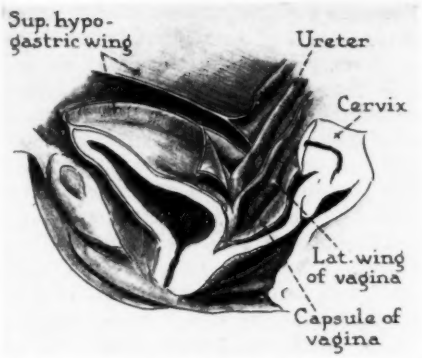

Fig. 9. Caudal portion of dissection shown in Figure 8 to show a further stage in this dissection. Capsule of vagina and its lateral expansion have been dissected away from the bladder and inferior hypogastric wing, respectively. The inferior hypogastric wing, with the ureter in it, is seen from a dorsomedial aspect, the lateral fascial wing of the bladder capsule presents its ventrolateral surface. The vesicovaginal space is exposed to view.

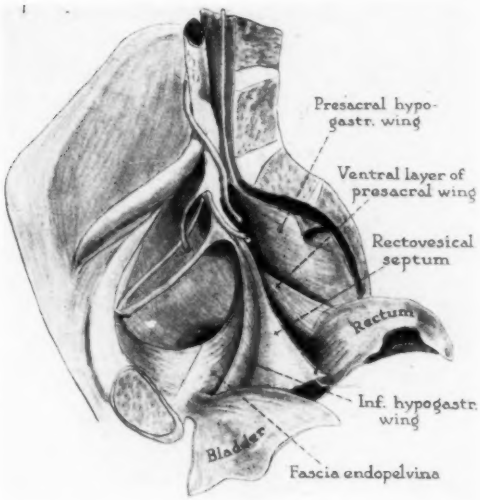

Fig. 9a. Right half of pelvis of white male (479ui, 1945) of 60 years of age. Peritoneum removed to expose elements of hypogastric sheath. Hypogastric root has been dissected away. Superior hypogastric wing was cut away. Bladder was cut away from inferior hypogastric wing and pulled out of the pelvis. Rectum pulled medially. The lateral margins of the inferior hypogastric wing, the rectovesical septum and the lateral fascial expansion of the rectal capsule are seen attached to the medial margin of the fascia endopelvina, like the leaves of a book.

tional evidence to show that the ureter, owing to its firm encasement between the two fascial leaves of the inferior hypogastric wing and its peculiar anatomical relationship with the uterine vessels, does not easily yield and is capable of aiding, under normal conditions of stress, in mooring the uterus to the inferior hypogastric wing. Incidentally it would seem that, in case of correctness of these assumptions, the strangulation of the ureter could be abolished by ligating and severing the uterine artery and relying on the ovarian artery for the blood supply of the uterus, especially so, as this latter artery plays the major rôle in the blood supply of the uterus after the first pregnancy.

On the basis of the evidence here presented, we come to the conclusion that the lateral root of the cardinal ligament does not lie opposite the ischial spine, but is located more than 1 inch ventral to the spine; that in the female alone a structure, the cardinal portion of the levator ani, is developed and that the specific function of this structure is to moor the root of the Mackenrodt ligament to the pelvic floor and thereby give support to the uterus.

ATTACHMENTS OF RECTOVAGINAL SEPTUM

Since the rectovaginal septum and its attachments are the cause of a subdivision of the subperitoneal space of the pelvic cavity into a rectal and a genitourinary compartment, it is appropriate, that this subject be discussed here somewhat more in detail. The dissections which elucidate this point, are illustrated in Figures 7 and 8.

With the aid of the fingers and a blunt instrument the rectovaginal septum was first separated from the rectum (Fig. 7) and then from the dorsal wall of the vagina (Fig. 8). In both instances it could be followed laterally beyond the lateral boundaries of the rectum and vagina to the medial margin of the fascia endopelvina, to which it was attached. At the same time a lateral wing of fascia arising from the capsule of the rectum and representing the caudal continuation of the presacral wing of the hypogastric sheath and a similar wing arising from the lateral margin of the vagina, could be demonstrated; the former is seen from its ventral aspect in Figure 7 as it extends laterally from the rectum, the latter is

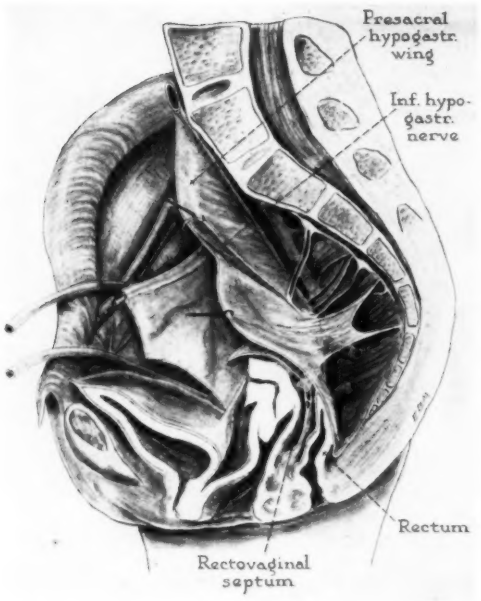

Fig. 10. Continuation of the dissection shown in Figure 9. The presacral hypogastric wing has been raised from the parietal fascia which is seen as it covers the coccygeus muscle, and has been reflected forward to permit a view into the retrorectal space. In this space are seen the autonomic nerves as they pass forward and laterally to pierce the dorsal layer of the presacral wing in order to enter the space between the two layers of the presacral wing and to join the pelvic ganglion; the latter has not yet been dissected out. The sympathetic branches arise from the sympathetic ganglia; the other branches are the parasympathetics, branches of the sacral nerves. In the retrorectal space are seen also the rubber tubes which were pushed through the floor of the space of Retzius to show the relationship between this latter space and the retrorectal space.

seen from its dorsal aspect in Figure 8, as it rises to its fusion with the cardinal ligament. Both the rectal and the vaginal wing extended laterally toward the fascia endopelvina, gaining attachment along the medial margin of this fascial plate, the former caudal and dorsal, the latter cranial and ventral to the line of attachment of the rectovaginal septum. In Figure 9, the ventrocranial surface of the vaginal wing is seen as it was displayed by dissecting it away from the inferior hypogastric wing which is illustrated with its medial leaf incised and reflected to show the structures that are contained in it (only the ureter has been illustrated).

From the description presented here, it follows that the medial margin of the fascia endopelvina represents a line along which, in the female, four leaf-like structures are attached; from ventrocranial to dorsocaudal these are: (1) the inferior hypogastric wing of the bladder, (2) the lateral fascial wing of the vagina, (3) the rectovaginal septum, and (4) the lateral fascial wing (caudal continuation of presacral hypogastric wing) of the rectum. Upon this line of attachment the four leaf-like structures can be turned like the leaves of a book. Grasping anyone of the three pelvic viscera, after the dissection illustrated in Figures 7, 8, and 9 had been finished, it could be freely moved back and forth upon its fascial wing.

In the male pelvis, owing to the absence of the vagina, there are present only three of these leaves. They are illustrated in Figure 9a: the fascia endopelvina is seen as it passes dorsally from the symphysis pubis to the spine; attached to its medial margin are the inferior hypogastric wing, the rectovesical septum, and the ventral layer of the lateral fascial wing of the rectum.

Returning now to the rectovaginal septum, it is seen in Figure 7, that it extended in this case, as it did in many other subjects, far up cranially along the lateral margin of the rectovaginal pouch (in Figs. 7 and 8), forming a lateral wing by means of which the pouch gained a firm attachment to the presacral hypogastric wing, lateral to the rectum and close to the origin of the presacral wing from the hypogastric root.

From this description it is obvious that owing to the presence of the rectovaginal septum and the nature of its attachments, the subperitoneal space of the pelvic cavity is divided into two strictly separated compartments, a dorsal or rectal compartment and a ventral or vesicovaginal compartment. Similarly, in the male, the rectovesical septum divides the subperitoneal portion of the cavity of the pelvis minor into a rectal and vesicoprostatic compartment.

THE FIVE FASCIAL SPACES OF THE PELVIC CAVITY

Altogether the subperitoneal space of the cavity of the female pelvis minor is subdivided

into five fascial spaces by four partitions; three of these are represented by the three major pelvic viscera, their fascial capsules and the lateral fascial extensions of these capsules, while one, the rectovaginal septum, is a fascioperitoneal sheet. In the male pelvis there are only four such fascial compartments.

These fascial spaces are illustrated in Figures 3, 7, 8, 9, and 10. They are, from ventrocranial to dorsocaudal: (1) the space of Retzius (lateral and ventral compartments) illustrated in Figure 3; (2) vesicovaginal space (Fig. 9); (3) retrovaginal space, between the vagina and the rectovaginal septum (Fig. 8); (4) prerectal space, between rectovaginal septum and rectum (Fig. 7); and (5) retrorectal space (Fig. 10) between the rectum and presacral hypogastric wing ventrally and parietal fascia dorsally.

THE LATERAL COMPARTMENT OF THE SPACE OF RETZIUS

Of these five fascial compartments the space of Retzius is the most spacious and extensive one. Because of its easy extraperitoneal access by the suprapubic route and because of its important relationships, the lateral compartment of the space of Retzius merits a special discussion of its boundaries and communications.

The lateral compartment of the space of Retzius may be said to have two side walls (a lateral and a medial wall), a floor and a roof, and a dorsal wall. Ventrally it is in open communication with its partner of the opposite side via the ventral compartment of the space of Retzius. Dorsally it extends as far as the ischial spine.

Its lateral wall consists of the parietal endopelvic fasciae covering the pelvic surfaces of the internal obturator and of that portion of the levator ani which lies cranial to the white line (origin) of the fascia endopelvina. In this wall are located the entrance into the obturator canal, the obturator vessels, and the obturator nerve.

The medial wall consists of the fascial capsule investing the inferolateral wall of the bladder and of the inferior wing of the hypogastric sheath and, more dorsally, of the forward extension of the hypogastric root. The

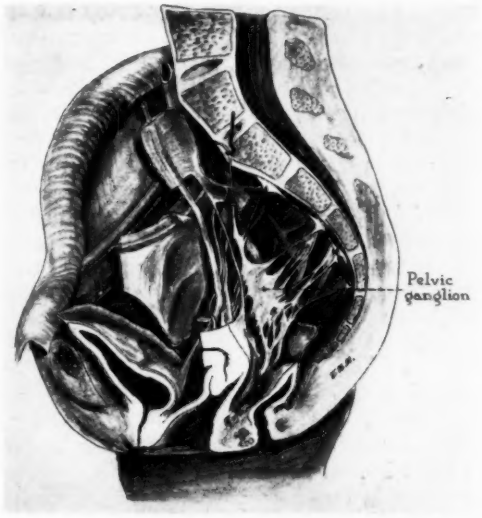

Fig. 11. A further step in the dissection shown in Figure 10. The ventral and dorsal layers of the presacral wing have been separated from one another to expose the pelvic ganglion which is enclosed in the space between the two layers.

inferior vesical vessels and their various branches, as well as the venous plexus of the bladder, and the ureter are located in this wall. The inferior hypogastric wing separates the space from the vesicovaginal space (Fig. 9); when the beam of a flashlight is thrown into this latter space, it can be seen in the space of Retzius as it shines through the inferior hypogastric wing.

The floor of the space (Fig. 3) is made up by the fascia endopelvina, differentiated in front into special vesical ligaments, the medial and lateral pubovesical ligaments and the lateral true ligament of the bladder. It extends as far dorsally as the ischial spine and forms an investment of the aponeurotic fibers of the three ligaments and, in the female, hides from view the portio cardinalis (Fig. 4) of the levator ani. Cutting through this fascia between the ischial spine and the dorsal end of the cardinal portion creates access to the retrorectal space and the dorsum of the rectum. Also the autonomic pelvic nerves can be reached in this way (Fig. 10) as will be shown later on.

The roof of the space is formed by the superior hypogastric wing (Fig. 3) which contains the umbilical artery and its superior vesical branches (Fig. 6). The roof excludes the round ligament of the uterus and the ovarian vessels in the female (Fig. 6) and the vas deferens in the male (Figs. 6a and 6b) from the space of Retzius.

The dorsal wall of the space is formed by the hypogastric root (Figs. 3 and 4); this contains the anterior division of the hypogastric vessels, the visceral branches of these vessels, and the ureter, and seals the space off against the retrorectal space and the rectum. Caudally this wall ends in the easily palpable inferior vesical arch (Fig. 4) which arises, laterally, from the ischial spine and conveys the inferior vesical vein and artery from, and to, the inferior hypogastric wing.

THE PELVIC GANGLION

The pelvic ganglion while it has received many excellent anatomical descriptions—the most recent one by Curtis, Anson, Ashley, and Jones (8)—and while it plays a major rôle in the control of the physiology of the pelvic viscera, is nevertheless seldom mentioned or considered in any way, in descriptions of surgical procedures, an indication that our anatomical accounts of this structure do not yet lend themselves to the use by the practitioner. We have studied the topography of this anatomical entity from many different angles and in respect to several of the most frequent surgical procedures, but are as yet unable to present this subject in a way easily applicable during the various pelvic operations. We have made several observations, however, which will be recorded here.

In some subjects it is possible to display, after removal of the loose connective tissue between the dorsal capsule of the rectum and the parietal fascia, a special sheath, the pararectal sheath which arises from the parietal fascia along a line corresponding to the anterior sacral foramina. This sheath contains between its two layers the pelvic autonomous nerves, conveying them to the presacral sheath with which it fuses. In the female cadaver described here, only parts of such a sheath (Fig. 10) could be displayed. After reflecting the presacral sheath (Fig. 10) forward, the individual nerves could be easily dissected. The inferior hypogastric nerve (see Curtis, Anson, Ashley, and Jones, 8, for nomenclature), which was only loosely embedded in the dorsal leaf of the presacral sheath, had been dissected out to the point where it received two branches from the second sacral sympathetic ganglion. Both the sympathetic and the parasympathetic branches are seen in Figure 10, as they pass, from their origins, laterally and toward the presacral sheath, piercing the dorsal leaf of the sheath and entering the space between the two leaves of the sheath.

The further course of these nerves is shown in Figure 11. The presacral sheath was split into its dorsal and ventral leaves, a procedure which succeeds easily if one begins with raising the ventral capsule of the rectum. The ventral leaf was carefully lifted away with a blunt instrument, and cut away close to the place where the presacral sheath arises from the hypogastric root. The peritoneum of the rectovaginal pouch (Fig. 10) was also cut away as it obstructed the view of the illustrator upon the nerves, but the most caudal portion of the rectovaginal septum is still in place. By these manipulations the pelvic ganglion is exposed as it lies in the space between the two leaves of the presacral sheath, close to where this sheath arises from the hypogastric root and where it is joined by the lateral extension of the rectovaginal septum.

The main extension of the ganglion, i. e. its longitudinal diameter, is from cranial to caudal. A finger thrust laterally either into the prerectal (Fig. 7) or retrovaginal (Fig. 8) space would arrive just about at the caudal end of the ganglion. As it lies sandwiched in between the two leaves of the presacral sheath, medial to the hypogastric root, it cannot be reached through the lateral compartment of the space of Retzius. If during a hysterectomy in the female or a cystectomy in the male the presacral sheath is left intact, the pelvic ganglion will not be injured. If in making access to the retrorectal space from the lateral compartment of the space of Retzius (see the rubber tubes *x* and *y* in Figs. 5 and 10) the finger is pushed into the retrorectal space along the route indicated by the cranial tube *x*, it

will be stopped by the sympathetic and parasympathetic nerves (or the pararectal sheath if that is present); to penetrate sufficiently far medially to reach the rectum, the finger or the instrument must be given a caudal direction in order that it may slip through underneath these nerves (see Fig. 10).

While the pelvic ganglion receives the hypogastric nerve at its cranial end and the sympathetic and parasympathetic branches at its dorsomedial margin, it gives rise to the branches of distribution at its ventrolateral margin and at its caudal end. We have not followed these branches to their terminations. The origins of many of them are seen, however, in Figure 11; they are joined in their course by a direct branch from the inferior hypogastric nerve. This as well as the ventral branches of the ganglion pass into the inferior hypogastric wing, evidently to be distributed to the uterus, vagina, and bladder. From the caudal end of the ganglion two stout nerves took origin, which were seen passing caudally between the rectal musculature and the ventral capsule of the rectum. An arrangement very similar to the one described here was found in several male cadavers.

SUMMARY

1. In the dissection of the pelvis of an adult female, supplemented by the dissection of several other pelves, the following components of the visceral endopelvic fascia were studied: (a) the hypogastric sheath, (b) the fascia endopelvina, (c) the cardinal ligament.

2. From the hypogastric root three fascial wings, a presacral, an inferior and a superior wing take origin. Each of these represents a well defined and easily demonstrable double layered fascial membrane of considerable firmness.

3. The presacral wing is associated with the rectum, the superior and inferior wings with the bladder.

4. The presacral wing absorbs the superior hemorrhoidal sheath, furnishes the capsule of the rectum, contains the pelvic ganglion between its two layers and, in combination with the hypogastric root, seals the retrorectal space off against the lateral compartment of the space of Retzius.

5. The superior hypogastric wing constitutes the roof of the lateral compartment of the space of Retzius, conveys the superior vesical arteries to the bladder, and excludes the vas deferens, round ligament of the uterus, ovaries and ovarian vessels from the space of Retzius.

6. The inferior hypogastric wing represents one of the major anchorages of the bladder. It conveys the inferior vesical vessels and the ureter.

7. Opposite the ischial spine the inferior hypogastric wing is firmly attached to the pelvic wall by the inferior vesical arch through which the inferior vesical vessels are passing on their way between the root and the inferior wing of the hypogastric sheath. Through the inferior vesical arch the bladder is moored to the pelvic wall, in the region of the ischial spine.

8. The cardinal ligament arises from the medial side of the inferior hypogastric wing, located at a point which is situated more than an inch ventral to the ischial spine. The place where the cardinal ligament is moored, laterally, to the pelvic floor, does not lie opposite the ischial spine, but more than an inch ventral to it, where the fleshy and aponeurotic fibers of the portio cardinalis, a part of the levator ani especially differentiated for that purpose in the female, pass from lateral to medial into the inferior hypogastric wing.

9. The fascia endopelvina (together with its ventral differentiations, the medial and lateral pubovesical ligaments and the lateral true ligament of the bladder) is attached laterally to the pelvic floor along the "white line of the fascia endopelvina." To its medial margin are attached, like the leaves of a book, four (three in the male) leaflike structures, the inferior hypogastric wing, the lateral fascial wing of the vagina, the rectogenital septum and the lateral wing (caudal portion of presacral sheath) of the rectum.

10. The lateral compartment of the space of Retzius does not extend as far dorsally as the rectum. At the level of the ischial spine it is sealed off against the rectum by the root of the hypogastric sheath.

11. Through the floor of the lateral compartment of the space of Retzius subperitoneal access can be created to the rectum.

12. The rectogenital septum, by its attachments, laterally, to the fascia endopelvina and presacral wing, partitions off the subperitoneal space of the pelvis minor into two compartments, a rectal and a urogenital.

REFERENCES

1. Brettauer, Joseph, and Rubin, I. C. Am. J. Obst., 1923, 6: 696-709.
2. Cameron, John. J. Anat. Physiol., 1908, 42: 112-125.
3. Ibid., 438-455.
4. Cuneo, B., Veau, V. J. anat. physiol., 1899, 35: 235-245.
5. Cunningham, D. J. Manual of Practical Anatomy. Vol. 1, p. 507, 3rd ed. Philadelphia: J. B. Lippincott Co., 1903.
6. Idem. Text Book of Anatomy. 1st ed., p. 409. New York: William Wood and Co., 1903.
7. Curtis, Arthur H., Anson, Barry J., and Beaton, Lindsay E. Surg. Gyn. Obst., 1940, 70: 643-656.
8. Curtis, Arthur H., Anson, Barry J., Ashley, Franklin L., and Jones, Tom. Surg. Gyn. Obst., 1942, 75: 743-750.
9. Derry, Douglas E. J. anat. physiol., 1908, 42: 97.
10. Douglas, James. A Description of the Peritoneum, and of that Part of the Membrana Cellularis Which Lies on its Outside, with an Account of the True Situation of all the Abdominal Viscera, in Respect of These Two Membranes. London: J. Roberts, 1730.
11. Everett, Houston S. Gynecological and Obstetrical Urology. Baltimore: Williams and Wilkins, 1944.
12. Hesselbach, Franz Caspar. Neueste anatomisch-pathologische Untersuchungen ueber den Ursprung und das Fortschreiten der Leisten-und Schenkelbrüche. Würzburg: J. Stahel, 1814.
13. Jewett, Hugh. Am. J. Ass. Genitourin. Surgeons, 1944, 37: 51-65.
14. Lowsley, Oswald Swinney, and Kirwin, Thomas Josef. Clinical Urology. Illustrated by William P. Didusch. 2d ed., p. 947, 3rd printing, 1946, Baltimore: Williams and Wilkins, 1944.
15. Peham, H. v., and Amreich, J. Gynaekologische Operationslehre. Berlin: S. Karger, 1930. (for "lockeres Bindegewebe" see p. 197). Also see English Translation by L. Kraeer Ferguson. Philadelphia: J. B. Lippincott Co., 1934. (For pelvic anatomy see vol. 1).
16. Testut-Latarjet. Traité d'anatomie humaine. 8th ed. Paris: Gaston Doin, 1931. (For parietal fascia see vol. 5, p. 304, for hypogastric sheath see vol. 5, p. 306).

THE HETEROLOGOUS GROWTH OF CANCER OF THE HUMAN PROSTATE

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THE growth of human cancer in an alien host offers an experimental approach to the study of the biological activity of malignant tissue. Human prostatic cancer in particular presents a type of malignant growth which may be investigated from the point of view not only of autonomous growth but also of endocrine factors. Previous experimental work on prostatic cancer has been limited to three methods of investigation: tissue culture *in vitro*, the effect of hormones on the prostatic gland of animals, and the stimulation with chemical carcinogens of susceptible strains of laboratory animals. Each of these methods has added knowledge, but the secret of causation and the cure of prostatic cancer have not yet been discovered. The object of this paper is to present for the first time the results of heterologous transplantation of carcinoma of the human prostate. This research also includes observations on the effect of hormone stimulation and the biologic activity of the enzyme acid phosphatase in animals with human prostatic cancer growing in the anterior chamber of the eye.

The tissue culture phase of the experimental work was stimulated by the demonstration in 1907 by Ross G. Harrison that normal frog tissues and cells could be cultivated outside the organism. Three years later Carrel and Burrows (3), using a modified and improved method of tissue culture, first observed the growth of human cancer cells *in vitro*. In 1917, Burrows, Burns and Suzuki (1) cultured tissues from cancers of the human bladder and prostate and studied the biologic changes which take place in cells outside the body.

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Burrows and Kennaway (2) attempted to produce cancer of the prostate in mice by the use of hormones. They observed that long continued estrogen injection caused squamous metaplasia of the prostatic epithelium, but no true adenocarcinoma of the gland resulted. Van Wagenen noted fibromuscular hyperplasia in the stroma of the prostate of macaque monkeys as the result of stimulation with large doses of estrin. Moore (8) reviewed the experimental problem of the production of cancer of the prostatic gland by hormones and concluded that in no instance had true adenocarcinoma resulted after the administration of either androgen or estrogen.

Working with the carcinogen benzpyrene Moore and Melchionni (9) caused squamous metaplasia of the prostate in rats after the injection of the chemical into the gland. Dunning, Curtiss, and Segaloff induced squamous cell cancer of the prostate in two inbred strains of rats by injection of methylcholanthrene into the prostatic gland and found that these cancers when transplanted to the subcutaneous tissues metastasized to the lungs and skeletal system.

In 1935, Heckel and Kretschmer transplanted homologously normal rabbit prostate into the anterior chamber of the eye, stimulated the transplants with pituitary-like hormones, and obtained growth of the prostatic transplant. More recently the successful heterologous transplantation of human cancers into the anterior chamber of the eye of alien hosts by Greene suggested a new experimental approach to the cancer problem.

MATERIALS AND METHODS

Guinea pigs were employed as the alien hosts in this investigation, and the specimen for transplantation was inoculated into the anterior chamber of the eye under sterile precautions. A frozen section of the original

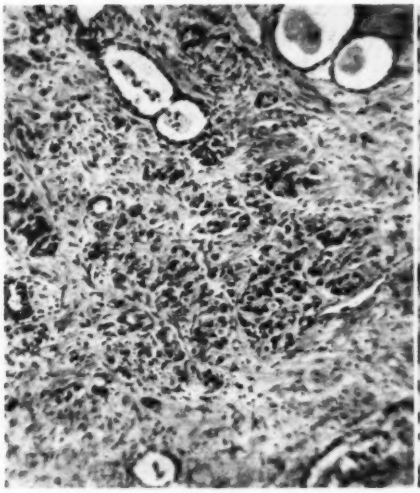


Fig. 1.

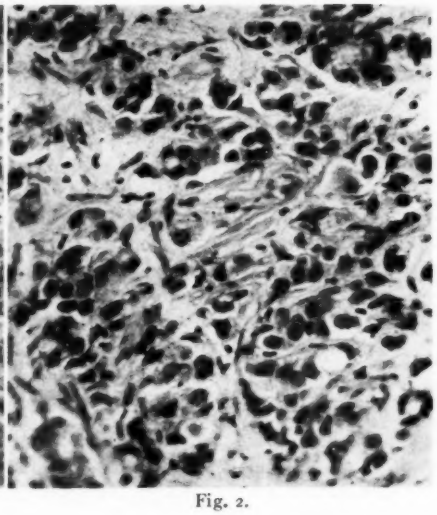


Fig. 2.

Fig. 3.

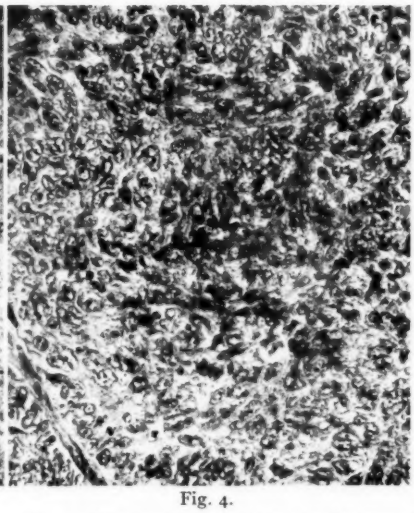


Fig. 4.

Fig. 1. Section of human adenocarcinoma of the prostate. Note large cuboidal cells invading the stroma of the gland. ×75.

Fig. 2. Higher magnification of human prostatic cancer. ×300.

Fig. 3. Metastatic node to left vas deferens of human prostatic cancer. Lesion is characterized by solidly packed cancer cells, adenoid in structure, with very little stroma. Portion of this tissue used for heterologous transfer. ×75.

Fig. 4. Higher magnification of metastatic lesion. ×300.

specimen was made before transfer to identify the tissue as a true cancer and to allow the experimenter to choose areas bearing relatively more cancer cells for transfer. The technique of an anterior chamber transplant was easily carried out. Using surgical precautions, the eye of the animal was anesthetized with a drop of 5 per cent cocaine, and the anterior chamber was opened at the corneoscleral junction by a quick stab with a corneal knife. A

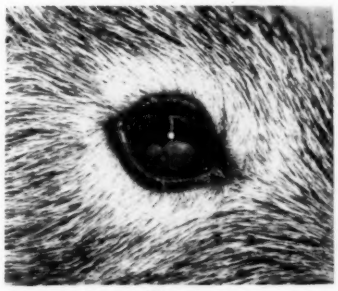


Fig. 5.

Fig. 6.

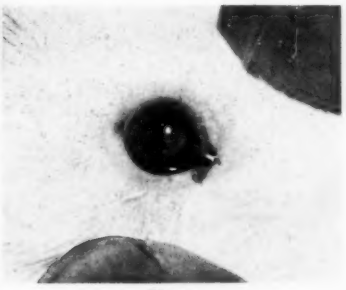


Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 5. Photograph of guinea pig (male) with anterior chamber transplant of human metastatic prostatic cancer after 22 days' growth.

Fig. 6. Second generation transplant (male) after 18 days. Note marked vascularity of growth. Chamber is half filled with tumor.

Fig. 7. Third generation transplant (male) after 20 days' growth.

Fig. 8. Fourth generation transplant (male) after 21 days' growth.

Fig. 9. Fifth generation transplant (male) after 22 days' growth.

Fig. 10. Fifth generation transplant (female) of prostatic cancer after 20 days' growth. Animal has been stimulated daily for a period of 35 days with 5 milligrams testosterone.

small fragment of tissue measuring about 0.5 millimeter in diameter was then introduced into the anterior chamber by means of a trocar. The tissue was guided to the lower angle of the iris by a blunt instrument. No further care was necessary, and the corneal incision healed rapidly.

CASE HISTORY

The tissue used in this heterologous transfer was removed from a metastatic lesion of cancer of the prostate involving the left vas deferens. In July, 1945, the patient, a 69 year old lawyer, was admitted to the hospital because of progressive diminution in size and force of the urinary stream. The family history was significant in that the patient's father had died at the age of 55 of cancer of the throat. The rectal examination was characteristic of an extensive malignant prostatic lesion. There had been no weight loss, nor was there any evidence by x-ray of bone metastases. Serum acid phosphatase was 6.95 King-Armstrong units.

Since the prostatic lesion was too extensive for total resection it was decided to establish a histological diagnosis and then to treat the patient by means of estrogen therapy. Perineal biopsy revealed an adenocarcinoma of the prostate gland characterized by irregularly growing sheets and strands of cuboidal cells invading the connective tissue (Figs. 1 and 2).

The patient tolerated estrogen badly, and, although he was on a dosage of 1 milligram daily, took it irregularly during the year, lost weight, and was generally unhappy. He did not develop any metastatic pain for 9 months. In May, 1946, 10 months after he was first seen, a metastatic x-ray series revealed extensive bony metastases involving the lumbar and sacral regions. A cystic mass the size of an egg had developed in the region of the left vas 3 centimeters above the testis. Serum acid phosphatase at that time was 4.2 King-Armstrong units. The patient consented to castration and the removal

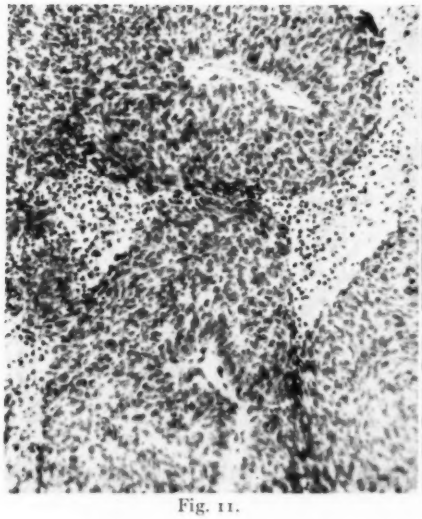
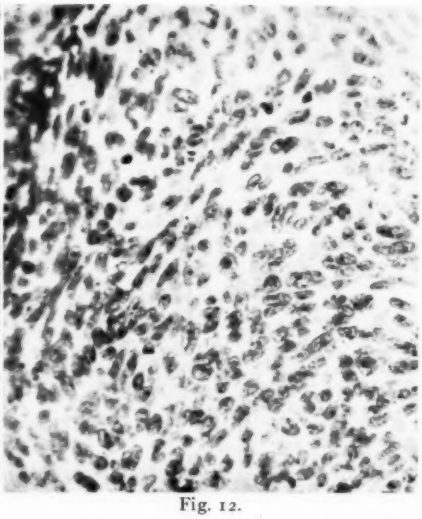


Fig. 11.



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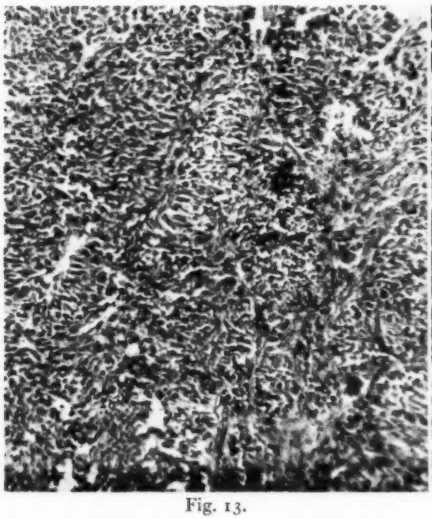

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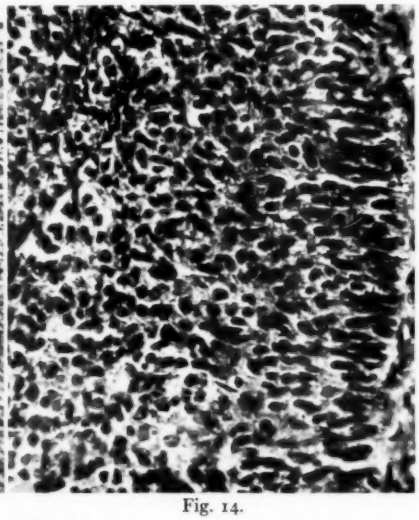

Fig. 14.

Fig. 11. Section of anterior chamber growth of human prostatic cancer, first generation. Adenoid nature of transplant is maintained. ×145.

Fig. 12. Higher magnification of first generation growth. ×300.

Fig. 13. Section of fourth generation anterior chamber growth. Morphological similarity to original human cancer is still apparent. ×145.

Fig. 14. Magnification of fourth generation growth. ×300.

of the inguinal mass. This tumor proved to be a metastatic lesion from the prostate. It was composed of cells arranged in gland-like formation, with hyperchromatic nuclei, pink-staining cytoplasm, and many mitotic figures. A portion was utilized for guinea pig transfer (Figs. 3 and 4).

Castration did not relieve the patient of his back pain, but when the estrogen dosage was raised to 15 milligrams daily the pain disappeared. At the present time this dosage is still being administered to the patient and he seems to be in fairly comfortable condition.

TABLE I.—RESULTS OF HETEROLOGOUS TRANSPLANTATION OF HUMAN PROSTATIC CANCER INTO THE EYES OF GUINEA PIGS

	Number of pigs		Number of takes		Takes per cent	
Generation	Male	Female	Male	Female	Male	Female
First	7	5	5	2–0*	71.4	0
Second	16	4	12	1–0*	75.	0
Third	22	5	8	0	21.5	0
Fourth	10	1	2	0	16.6	0
Fifth	6	0	2	0	33.3	0
Sixth	7	1†	1	1†	14.0	100.
Totals	68	16	30	1†	47.1	6.2

*Initially "takes" but within 10 to 12 days regressed.
†Received 5 mgm. testosterone daily for 35 days starting with the day of transfer.

These details are presented to show the course of a vigorously growing prostatic malignancy.

RESULTS

The first transfer was made on August 13, 1946, at which time 12 guinea pigs were inoculated, 7 male and 5 female. The usual course of an anterior chamber transfer ensued. The primary period of foreign body reaction was followed by a clearing of the chamber in 6 to 7 days and then rapid vascularization of the transplanted tumor. In 2 to 3 weeks growth was usually evidenced by increase in size and the presence of healthy pink coloration of the new tissue growth. On the average the latent period between transfer and growth was 15 to 20 days, although the period became successively shorter in later generations. When the eye was half or more filled with tumor growth the animal was sacrificed and part of the transplant was transferred to another generation of animals. In 6 serial generations of transfer a total of 84 animals were used, 68 male and 16 female. Throughout all the generations of transfer the cellular morphology seen in the parent human tumor was maintained. The stroma of the transfer represented the result of the guinea pig reaction to a foreign tissue, but the actual cancer cells were a reproduction of the original human tumor cells. These cells reproduced the tumor histologically but biologically differed in that there was a recession of production of acid phosphatase enzyme (Figs. 11, 12, 13, and 14).

TABLE II.—RESULTS OF HORMONE STIMULATION AND CASTRATION OF GUINEA PIGS WITH TRANSPLANTED HUMAN PROSTATIC CANCER

Generation	Number of pigs		Testosterone stimulated		Controls		Castration		Takes after castration	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
Third	22	5	4*	–	4	–	–	–	–	–
Fourth	10	1	–	1*	–	0	2	–	0	–
Fifth	6	0	–	–	2	–	–	–	–	–
Sixth	7	1	1*	1†	–	–	2	–	0	–
Totals			5	2	6	0	4		0	

*Stimulation with 1 mgm. testosterone daily for 30 days with equivocal results.
†Stimulation with 5 mgm. testosterone daily for 35 days.

The results of serial transfers to the anterior chamber of the guinea pig are shown in Table I.

A. Hormonal factors. During the first two serial generations of heterologous transfer natural growth was allowed to take place. Beginning with the third generation castration and androgen stimulation were added to the experiment. These results are summarized in Table II. Successful "takes" occurred in 33 animals, slightly less than one-half, but only 1 of these "takes" occurred in a female animal. This female guinea pig was stimulated with a tremendous dosage of testosterone, 5 milligrams daily, for 35 days starting with the day of transfer.

Of 8 animals with successful "takes" in the third generation, 4 were stimulated with testosterone, 1 milligram daily, for 30 days, but no particular increase in rate of growth occurred as compared with 4 animals with successful "takes" used as controls. The eye filled up one-half to full in these cases, but the controls grew just as fast, and no definite conclusions could be drawn as to the positive effect of testosterone. Examination of microscopic sections of the testes of the animals stimulated with androgen did not show any changes. Two male animals in each of the fourth and sixth generations were castrated prior to transfer of the tumor. None of these male castrates developed successful "takes" from the transplanted tumor. In 15 female guinea pigs inoculated with human prostatic cancer not 1 animal developed a successful "take." When

TABLE III.—PHOSPHATASE LEVELS OF GUINEA PIGS WITH AND WITHOUT PROSTATIC CANCER GROWING IN THE ANTERIOR CHAMBER OF THE EYE (KING-ARMSTRONG UNITS)

Pig Number	Tumor-bearing animals			Controls	
	Generation	Acid phosphatase	Alkaline phosphatase	Acid phosphatase	Alkaline phosphatase
1				14.1	16.1
2	First	11.8	14.3		
3				8.1	10.5
4				7.3	6.4
5	Second	9.9	8.7		
6				10.9	16.7
7				8.4	13.1
8				1.4	10.6
9	Third	6.1	9.7		
10	Fourth	14.5	16.7		
11				11.1	12.8
12				7.9	10.4
13				12.6	10.6
14				9.4	14.4

testosterone in massive doses, 5 milligrams daily for 35 days starting with the day of transfer, was given a successful "take" did occur in a female guinea pig. Microscopic examination of the endocrine organs of this animal did not reveal any marked cellular changes. The ovaries had formed follicles and corpora lutea, and the pituitary and adrenals appeared normal.

The fact that the prostatic tumor did not grow in female animals and could not be transferred to castrated males took on a significant meaning since previous attempts to transplant a metastatic node from a proved case of carcinoma of the prostate had failed, although the transplants seemed to remain alive for some time. On reconsidering these facts it was found that all the animals used in this previous unsuccessful transfer were females.

B. Enzyme factors. Serum acid phosphatase levels were determined in normal guinea pigs and those having prostatic cancer transplants growing in the anterior chamber. This technique was easily performed by anesthetizing the animals and performing cardiac paracentesis. The heart blood was then measured for the presence of phosphatase in King-Armstrong units. The blood phosphatases for normal and tumor bearing animals did not differ as shown in Table III.

The serum acid phosphatase level of guinea pigs was not affected by the presence of human prostatic cancer growing in the anterior chamber of the eye. The results obtained from both normal and tumor bearing animals varied greatly, but no marked difference resulted from heterologous transplantation. Phosphatase stains on sections of transplants in the fourth and sixth generations failed to show the presence of enzyme. The regression of production of acid phosphatase enzyme in heterologously transplanted human prostatic cancer as shown by negative phosphatase staining reaction corroborated the finding of absence of elevation of blood serum acid phosphatase reading in tumor bearing animals. The transplanted cancer, therefore, must have undergone a change in biological activity in the guinea pig, although the morphological structure of the tumor remained the same as the original human cancer.

An attempt was made to determine whether the enzyme acid phosphatase was produced by the cellular nucleus or cytoplasm. Human benign and malignant prostatic tissue was first emulsified in a Ten Brock homogenizer and then centrifuged at high speeds to isolate the cell nucleus from the cytoplasm. These constituents were then stained for phosphatase content. The amorphous cytoplasm of centrifuged prostatic cellular material gave a much heavier stain for phosphatase than did the nuclear portion of the cell, indicating that the greater part of the enzyme acid phosphatase was a component of the cytoplasm of the prostatic cell.

COMMENT

The growth of human prostatic cancer in an alien host proves conclusively that this cancer is an autonomous growth. The results of heterologous transplantation of human prostatic cancer using the guinea pig as the alien host have indicated that this cancer is influenced by hormonal factors within the animal. Lack of growth of transplanted prostatic cancer in female animals implies that the male hormone must be present for the growth of this tumor.

Similarly, human clinical experiences have revealed that cancer of the prostate has not been found in eunuchs. No cellular changes were found in the testes of guinea pigs stimulated with testosterone. The endocrine system of a female guinea pig stimulated with massive doses of androgen did not show any cellular changes. Testosterone or one of its constituents, therefore, must be present for the growth of prostatic cancer in male animals, but this experimental study suggests that the actual amount of the substance is not important, since control animals grew tumors just as rapidly as testosterone stimulated males.

The inherent ability of prostatic cancer cells to produce the enzyme acid phosphatase disappeared on heterologous transfer. The absence of the enzyme activity in tumor growing in the guinea pig eye was corroborated by the finding of no elevation of blood phosphatase levels and by the results of tissue stains. The enzyme acid phosphatase is a product of cellular metabolism and is produced by both nucleus and cytoplasm. Although the enzyme activity of the prostatic cell changed on heterologous transfer the transplanted tumor retained its autonomy and was transferable to succeeding generations. One can, therefore, postulate that the all-important part of the cell in malignant growth is the nucleus. It is the cellular nucleus, then, which is the portion of the malignant cell that does not alter its character but keeps on growing wildly in spite of the alien host or environment. This cellular nucleus must hold the key to the answer why malignant cells set up an autonomy and characteristic trait of disordered, uncontrolled, cellular growth and metabolism.

Heterologous transplantation presents a method of investigation of human cancers to elicit the effects of biologic agents, carcinogens, hormones, and perhaps even cancer-lytic substances upon malignant growth.

CONCLUSIONS AND SUMMARY

1. Cancer of the prostate gland has been successfully transplanted heterologously in guinea pigs for the first time, demonstrating the autonomous nature of this cancer.

2. By serial transplantation of this malignant tumor it has been shown that prostatic cancer is under the influence of endocrine factors.

3. When transplanted heterologously in male castrated guinea pigs, human cancer of the prostate did not grow. Similarly in human clinical observation cancer of the prostate has not been found in eunuchs.

4. Stimulation of female guinea pigs with small amounts of androgen did not affect the growth of transplanted prostatic tumor but stimulation of a female with massive doses aided in establishing a successful take of prostatic cancer.

5. Carcinoma of the human prostate heterologously transplanted in guinea pigs lost a fundamental biological activity, the production of the enzyme acid phosphatase. This fact was demonstrated by the absence of elevation of blood phosphatase level in tumor-bearing animals and absence of stain for phosphatase in sections of tissue removed from the guinea pig eye.

6. Heterologous transplantation of human prostatic cancer has indicated that the cellular nucleus holds the key to the biological activity of malignant cells which have become autonomous, disordered in growth and uncontrollable in cellular metabolism.

REFERENCES

1. BURROWS, M. T., BURNS, J. E., and SUZUKI, Y. J. Urol., Balt., 1917, 1:3.
2. BURROWS, H., and KENNAWAY, N. M. Am. J. Cancer, 1934, 20:48.
3. CARREL, A., and BURROWS, M. T. J. Exp. M., 1910, 13:571.
4. DUNNING, W. F., CURTISS, M. R., and SEGALOFF, A. Cancer Res., 1946, 6:256.
5. GREENE, H. S. N. J. Exp. M., 1941, 73:475.
6. HARRISON, R. G. Proc. Soc. Biol. Med., 1907, 4:140.
7. HECKEL, N. J., and KRETSCHMER, H. L. Surg. Gyn. Obst., 1935, 61:1.
8. MOORE, R. A. Surgery, 1944, 16:152.
9. MOORE, R. A., and MELCHIONNI, R. H. Am. J. Cancer, 1937, 30:731.
10. VAN WAGENEN, G. Anat. Rec., 1935, 63: 387.

STUDY OF URETERAL BLOOD SUPPLY AND ITS BEARING ON NECROSIS OF THE URETER FOLLOWING THE WERTHEIM OPERATION

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THE radical, or Wertheim, operation for carcinoma of the cervix uteri occasionally results in serious damage to the ureter, necrosis and fistula formation occurring in 6 to 10 per cent of cases (15, 57, 23). Meigs (33), the current champion of the Wertheim operation, reported 12.3 per cent spontaneous ureteral fistulas, in his last series published. However, this figure has been sharply reduced in his most recent cases in which he carefully avoided injury to the major ureteral vessels. Such injury has been a factor not only in primary operative mortality and morbidity, but has often necessitated nephrectomy or other surgical procedures which in themselves may be serious. Anspach, in reviewing the problem of cancer of the cervix since the introduction of radium therapy in 1912, predicts that despite the great improvement in results from surgery the morbidity from ureteral injury will still remain. Lynch (25) remarks that the radical operation is justifiable when it can be done, not only with little or no mortality, but with the avoidance of fistula and other major morbidity. Meigs (32, 33), in spite of his zero mortality rate, thinks the greatest drawback to the operation is ureteral injury, and insists that its incidence must be lowered. Most authors have reported that this complication is primarily brought about by an interference with the blood supply of the ureter incurred during the operation. Meigs (33) in his most recent report on the Wertheim operation, states that with better understanding of the ureteral blood supply, fewer ureteral fistulas should develop. It is hoped that a study of the ureteral blood supply may bring to light some facts which may aid in reducing this serious complication.

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It seems pertinent that a brief account of the genesis of the Wertheim operation and a review of the more recent literature concerning it be included in this discussion.

In 1878, Freund operated by the abdominal route on a patient who had carcinoma of the cervix. His procedure became the basis for all successful operative methods for this malady. In 1895, Clark, Ries, and Rumpf, suggested a more radical procedure which included removal of the pelvic lymph nodes. Wertheim's extensive series is credited with popularizing the operation, which since has been known as the Wertheim operation. This operation, connotes the removal, through the abdominal route, of the uterus and adnexa and by the use of clamps as much of the vagina as possible. The ureters are dissected and freed bilaterally to enable the operator to remove as much parametrium as feasible and finally to extirpate all enlarged pelvic lymph nodes. It is during the dissection and freeing of the ureters along their courses through the parametrium that injury in one form or another may occur. Since this study is limited to necrosis and fistula formation as a result of injury to the blood supply of the ureter, those injuries due to cutting, clamping, or ligating the ureter will merely be mentioned, although Bland, Feiner, and Adams have shown that all types of injuries to the ureter are very frequent complications of this type of operation.

Until recently in this country, the mere mention of the Wertheim operation brought forth strong protest from the majority who are called to treat carcinoma of the cervix. Many have considered, and some still hold, that the percentage of cure resulting from this formidable operation is not high enough to

compensate for the inherent high mortality and morbidity rate. Henry Schmitz, once wrote "If Shakespeare were alive today he might have written 'The evils of carcinoma operations live after them; the good is oft interred with their bones'."

Meigs (32, 33, 34), dissatisfied with the results obtained after radiation therapy, became interested in Taussig's work (51, 52, 53) on iliac lymph adenectomy combined with radiation. He decided to employ radical surgery in selected cases, in the form of the Wertheim technique, utilizing Taussig's method of lymph node dissection. His rationale is based on six points: "(1) If the cervix has been removed there is no chance of a recurrence in it. (2) If the cervix has been removed no cervical cancer can regrow in it as a recurrence. (3) Certain cancers of the cervix are radioresistant. (4) There will be less damage to the bowel if surgery is undertaken. (5) Patients with lymph node metastasis can be cured by surgery in some instances. (He does not believe it possible to cure by means of radiation metastasis in lymph nodes deep in the pelvis.) (6) With the cervix removed it cannot become the nidus of a recurrence or a new tumor." Bushke and Cantril report that 20 per cent of stage I and 30 per cent of stage II cases are not cured by even the most competent and skilled radiotherapist, but they suggest that possibly these figures may be reduced by improvement of radiation therapy. These authors state that "Granted that irradiation therapy cannot sterilize lymph node metastasis, Meigs has saved 9 cases. However, in accomplishing this, 20 patients have had to have Wertheim operation to save 3 that could not be saved otherwise." Meigs (35) has performed 100 Wertheim operations without a single operative death. His mortality rate is the lowest ever reported for this procedure and is a far cry from the high primary mortality rate that one finds reported in the earlier accounts. According to Martzloff there is a third era probably at hand, a period of a more rational employment of surgery or irradiation or both, to serve until such time as some more fundamental solution of carcinoma treatment is developed. Martzloff's statement is supported by a survey of the recent literature.

Counseller reports that the Mayo group has done a total of 113 Wertheim operations in the last 10 years, with results approximating those of Meigs. They feel that the Wertheim procedure should be given consideration in selected cases. McMurray believes that the entire armamentarium available for therapy must be utilized and that there are definite indications for x-ray, radium, and surgery. Morton (37) reports 100 cases of carcinoma of the cervix treated surgically by the Wertheim technique with over-all primary mortality of 6 per cent. Of these cases, 78 patients were operated on in the last 20 years with a mortality of 2.7 per cent (a rate lower than in total services which include the earlier operations). He (38), also does a pelvic lymphadenectomy along lines set forth by Taussig (51). Lynch (26, 27), and Taussig (53) advocate the Wertheim operation in early cases. Weaver (54), subdividing Group I of the League of Nations combined with Martzloff's or Broder's cellular classification, recommends a combination of surgery, x-ray, and radium, in these early cases. Bonney (4), Goodwin, Schlink and Chapman, and Maguire, all of the British Empire, are among the current proponents of surgical treatment.

It is apparent that many surgeons are cautiously returning to surgical therapy either alone or in combination with radiation. This we believe is the result of two factors: (1) The mortality rate has now approached a figure compatible with the operation's continued use. This has been the result of proper and careful selection of cases for surgery, improved surgical technique, better anesthesia, the use of preoperative radiation to "sterilize" the cervix, transfusions of whole blood and plasma and the sulfa drugs and the antibiotics. (2) A desire to better the current percentage of salvages by utilizing every available means of treatment.

Skinner sums the whole problem of treatment of cervical carcinoma as it stands today by stating that "we now enter into a desperately competitive era of research; pathological studies; irradiation; surgical liberties, tempered only by mortality; surgical advances, impeded by unpleasant morbidity statistics, anesthesia progress, hospitalization, and most

important, a public response to lay education and increasing support to lay activity.

ETIOLOGY OF SPONTANEOUS URETERAL FISTULAS FOLLOWING THE WERTHEIM OPERATION

Concerning the etiology of spontaneous fistulas following the Wertheim operation, one may note that these have occurred in practically every series reported. Wertheim felt sure that they were due to a disturbance of the blood supply of the ureter leading to a subsequent necrosis of that organ. Weibel noted that these fistulas occur in the easy operations as well as in the difficult ones where extensive isolation of the ureter must be carried out. Since these fistulas appear at the place where the ureter runs through the parametrium, he postulates that this constitutes a *locus minoris resistantiae*.

The majority of reports indicate that, as Wertheim postulated, the main factor is a disturbance of the blood supply of the ureter. However, not all authors are of this opinion. Frommolt (14), believing the vascular anastomosis of the ureter to be so efficient that injury of its blood supply is of no great moment, blamed necrosis and subsequent fistula formation on direct injury to the ureteral wall. Weibel believed that there may be several factors at work; ligatures too near the ureter, kinks of the ureter, infections, etc. Stoeckel held that postoperative kinks of the ureter are more important than injury of the blood supply. Some German authors felt that if necrosis were due solely to a destruction of the blood supply to the ureter the incidence of necrosis and fistula formation should be very high because most surgeons stripped the ureter of its incoming blood supply for great distances. Fitel, at Wertheim's request, studied the blood supply of the ureter and showed that the upper part of the ureter was supplied on its medial side from the aorta, common iliac, and internal iliac arteries. The lower part was supplied by vessels lateral to the ureter, i.e., the uterine and vesical arteries. He therefore deduced that to avoid injury to these vessels when exploring the pelvic ureter, the peritoneum above should be incised laterally, the incision being carried down on the medial side of the ureter. Sampson (44) noted that although Wertheim following Fitel's suggestion was apparently preventing necrosis by this method of incision, by remaining medial to the ureter, he also ran the risk of leaving carcinomatous parametrium behind.

Sampson (44), following injection studies of the ureteral vessels in cadavers and experimental studies on dogs, came to the conclusion that the protection of the periureteral sheath and its enclosed periureteral vascular anastomosis was of more importance than was the avoidance of injury to the main vessels themselves. We believe that Sampson and Fitel were both correct in that it is of the utmost importance to preserve both the periureteral plexus of vessels and the ureteral arteries themselves, and in particular the main ureteral artery or arteries, for the more blood supply to the ureter the less the chance for necrosis whether the ureteral wall has been injured or not. There may well be accessory etiological factors which play a part in certain cases, but such instances are believed to be in a minority.

Sampson (45) considers the following factors as possibilities in addition to injury to the periureteral sheath and its vascular plexus: (a) ligation of vessels supplying the plexus; (b) prevention or interference with the formation of adhesions which splint the ureter (exudates, gauze packs, infection, cauterization of the ureteral tissue bed, or mass ligatures; (c) pressure on the ureter; (d) stricture below ureteral injury; (e) general lowered resistance of the patient.

THE BLOOD SUPPLY OF THE HUMAN URETER AND ITS RELATION TO URETERAL FISTULAS

Anatomical texts (10, 17, 46) mention the blood supply of the human ureter in one or two brief sentences. A. V. Haller was the first to give an adequate description of the ureteral blood supply. He recognized that the upper third of the ureter was supplied by the renal artery, the middle third had an artery of its own and the lower third received branches from the vesical arteries and the uterine arteries. A review of the literature (12, 15, 19, 40, 42, 44) reveals that there have been but few who have studied this subject in any detail.

When the present study was undertaken it was thought that ordinary dissection of the

TABLE I.—ORIGIN OF URETERAL ARTERIES AS FOUND IN DISSECTION OF THE URETERS IN SEVEN STILLBORN INFANTS

	Subject	Renal artery	Internal spermatic (ovarian) artery	Abdominal aorta	Common iliac artery	Hypogastric artery	Uterine artery	Superior vesical artery	Middle vesical artery	Inferior vesical artery	Middle memorandum artery
1 M.	Right ureter	2	1	1	1	1	—	0	0	2	0
	Left ureter	2	1	0	1	0	—	0	0	2	0
2 F.	Right ureter	1	0	1	0	0	1	0	0	1	0
	Left ureter	2	1	1	1	0	1	0	0	1	0
3 M.	Right ureter	1	0	0	0	2	—	1	0	1	0
	Left ureter	1	0	0	0	1	—	1	0	1	0
4 M.	Right ureter	2	(accessory) 1	0	0	1	—	1	0	2	0
	Left ureter	2	1	0	1	0	—	1	0	1	0
5 M.	Right ureter	2	(accessory) 1	1	0	1	—	1	0	1	1
	Left ureter	1	1	1	0	1	—	0	0	1	0
6 M.	Right ureter	3	0	1	0	1	—	0	0	1	0
	Left ureter	1	0	1	2	0	—	1	0	1	0
7 F.	Right ureter	1	0	0	1	1	1	0	0	1	0
	Left ureter	1	0	0	1	0	1	1	0	1	1

From the above chart one may conclude that the main blood supply to the ureter may be multiple; their source being either the abdominal aorta, common iliac, or hypogastric arteries or a combination of these. The main blood supply may thereby be endangered in freeing the ureter through its pelvic course or during pelvic lymphadenectomy. The ureteral branches from the renal, uterine and vesical arteries are constant but short local branches. These, however, play an important part in the periureteral anastomosis. Ureteral branches from the internal spermatic (ovarian) arteries are inconstant and are generally small twigs.

cadaver would supply the needed information. However, difficulties were encountered in exposing the minute vessels, and after dissecting several adult subjects this was abandoned. It was then decided to work on fresh stillborns, using an injection mass to facilitate identification and dissection of blood vessels. Since colored synthetic liquid latex has been used to study the blood supply of various organs and tissues with great success it[1] was chosen for this study. As shown by Lieb (24), the substance penetrates even the smallest vessels. Such injected preparations lend themselves to corrosion and clearing.

The apparatus used for perfusion was a simple one patterned after that described by Narat, Loef, and Narat, consisting of two pressure bottles with a mercury manometer hooked in by means of a Y-tube to allow for pressure readings. Perfusion of the specimens was carried out through the descending thoracic aorta, tap water being used at 50 millimeters of mercury for 1 hour then 100 to 120 millimeters from 4 to 6 hours. After difficulty was experienced with leaks in the vascular system in the first two specimens the abdominal cavity was subsequently left unopened except for a small slit in the left lower abdominal quadrant. This not only acted as an escape for the intraperitoneal accumulation of fluid but also allowed a small segment of the small intestine to be drawn out and observed during the injection of the liquid latex, thus noting the progress of arterial filling. During perfusion the specimen became notably swollen but after having been placed in a refrigerator over night the edema practically disappeared.

A small compressor motor was used to inject the mass, at a pressure of 120 millimeters of mercury. The injection was done as soon as the specimen had returned to room temperature. All injections were done through the descending thoracic aorta and any leaks which had not been previously cared for were immediately stopped by applying a pledget of cotton moistened with a few drops of acetic acid. Following the injection the specimen was placed in a large jar of 5 per cent acetic acid and 10 per cent formalin, the abdomen

[1] Neoprene.

being opened to admit the fixing fluid. After 12 to 24 hours in this medium the specimen was removed and the ureteral blood supply was dissected out with the aid of a magnifying loupe. The ureteral vessels in the fetus are extremely small and delicate, but their consistency after injection allowed for a satisfactory dissection. Though no attempt was made to corrode these specimens, two block dissections of the abdomen and pelvis were cleared in wintergreen oil to afford a closer study of these fine vessels.

A total of 16 ureters were studied in 8 specimens but due to a seemingly incomplete injection of one, only the results as found in 7 fetuses will be considered in this paper (see Table I). Before presenting the detailed findings in 2 of these specimens a general description of the blood supply to the ureter as found during this study will be given.

The ureter receives its chief blood supply from what may be called long arteries which arise either from one or more of the following major vessels: the lower end of the abdominal aorta, just before its bifurcation, the common iliac artery, or the hypogastric artery. Where the origin is from the common iliac or hypogastric the ureteral arteries invariably arise from the medial side of these vessels and cross the artery of origin laterally to reach the medial side of the ureter where it divides into a T, with an ascending and a descending branch which may course for practically the whole length of the ureter. These longitudinal branches are of the same caliber as the ureteral artery and are found in the loose adipose areolar tissue capsule of the ureter. These ascending and descending primary branches anastomose with similar branches above from the renal, spermatic or ovarian arteries and below with similar branches from the uterine and vaginal arteries in addition to branches from the inferior and occasionally the superior vesical and middle hemorrhoidal arteries. In most instances the branches from the renal, spermatic (ovarian), uterine, vaginal, and the inferior vesical arteries may be considered as arteries which mainly supply that part of the ureter in their immediate vicinity. In several cases the main blood supply to the ureter was found to be multiple.

As first noted by Fitel, the arteries to the upper portion of the ureter (renal, aorta, common iliac, and hypogastric) reach the ureter on its medial side while those supplying the terminal portion (uterine, vaginal, and vesical branches), reach the ureter on the lateral side. The long ureteral arteries in turn give off many small branches which ramify around and over the ureter, anastomosing with each other on all sides above and below from the renal pelvis to the bladder. These secondary branches in turn give off many minute branches which pierce the muscular coat of the ureter. Details of the anastomoses of these terminal branches were not determined, but it is evident, as Sampson (44) has reported, that anastomoses of this third set of arteries are not as abundant as in the other two sets. Serial cross sections of ureters obtained from two adults at postmortem examination during this study revealed a rich blood supply of the muscularis and mucosa but no definite anastomosis of these vessels could be determined. Frommolt (15), however, claims that these fine branches anastomose with each other in the muscular coat of the ureter. In contrast to the longitudinal branches, the secondary branches of the ureteral arteries are quite closely adherent to the muscular coat, and these are not likely to be injured except by direct trauma whereas the primary long ureteral branches may be readily damaged in either dissection of the ureter from the parametrium or during pelvic lymphadenectomy.

It has been demonstrated in dogs (29, 44) and in man, (15, 20, 56), that the ureter may be isolated or stripped for relatively great distances without subsequent necrosis. The safety factor lies in the multiple blood supply to the ureter and the rich anastomoses of the primary and secondary branches of the ureter not only locally but from the kidney pelvis to the bladder. Sampson (44) demonstrated this by studying the efficiency of the ureteral blood supply by injecting a mass through various ureteral arteries. Therefore, if one ureteral artery is destroyed it may be possible for other branches to take over the blood supply. That this is true is not disputed, for in hundreds of Wertheim operations where the ureter has been described as "running through the pelvis

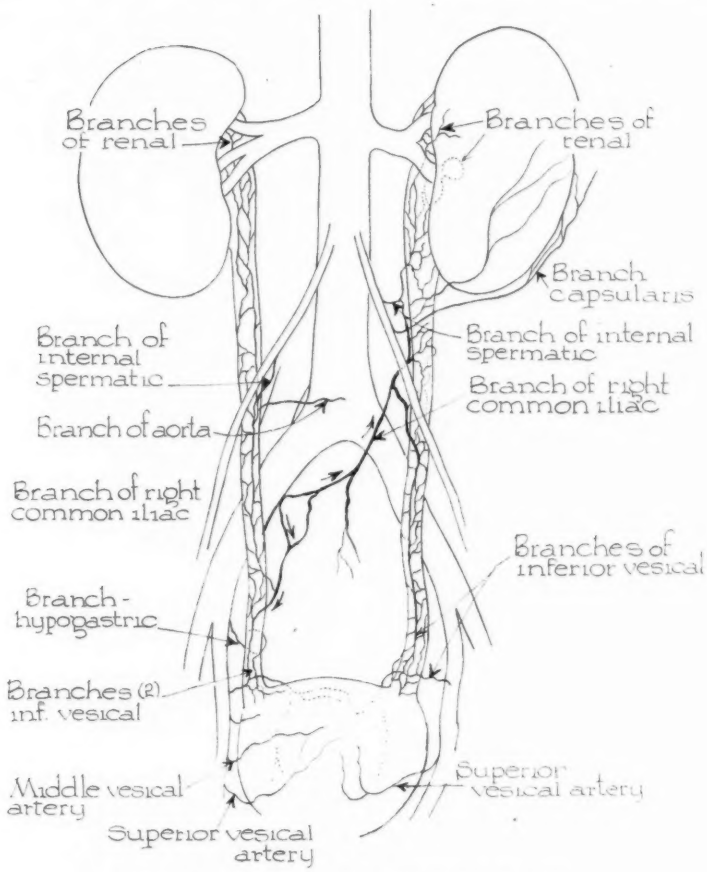

Fig. 1. Arterial blood supply of ureters of the male.

like a telephone wire" following its free dissection relatively few fistulas have developed. However, there must be cases of failure of this remarkable collateral circulation due to excessive robbing of blood supply coupled with vasospasm or disturbance by exudates, hematomas, trauma, and other pathological conditions of the secondary vessels of the ureter. There must be cases also in which the finer secondary branches which firmly cling to the ureter are directly traumatized in a limited region; this may not be evident at the time of operation. Another factor is that carcinoma of the cervix occurs in the later decades of life, when the smaller arteries and arterioles may have become less efficient as a result of changes associated with age.

It is obvious that to guard against necrosis of the ureter it is imperative to minimize damage to the ureteral blood supply during isolation of the ureters in the Wertheim operation. It is not advisable to ligate the internal iliac artery routinely as this may readily predispose to a further cutting down of the blood supply to the pelvic ureter. The branches of the uterine and vaginal arteries must of necessity be destroyed during the operation and the vesical branches are often inadvertently injured because of their positions. The burden may therefore rest with the main ureteral

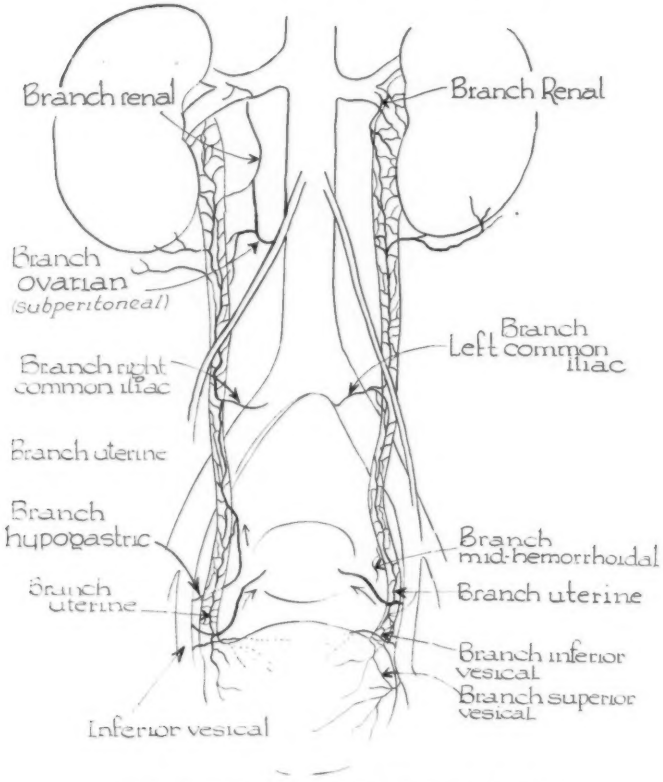

Fig. 2. Arterial blood supply of ureters of the female.

arteries and injury to these especially is to be carefully avoided throughout the operation especially during lymphadenectomy. Though nothing has been said concerning the venous drainage of the ureter it stands to reason that these companion vessels which generally follow the course of the arterial supply to the ureter must also be protected from injury wherever possible.

Since it is the general consensus (56, 21, 36) that the nerve supply of the pelvic ureter is the hypogastric plexus, we suggest that, as an aid in prevention of ureteral necrosis and fistula formation, the hypogastric plexus be either adequately blocked or resected during the performance of the Wertheim operation, thereby increasing the blood supply to the pelvic ureter by interrupting many of the vasoconstricting fibers to it. Collins had been carrying out this prophylactic procedure during the Wertheim operation. It is believed that such a procedure will not be an additional risk to the operation.

The following are brief summaries of the ureteral blood supply as found in Cases 1 and 7.

CASE 1. Colored male, premature, death at 21 days (Fig. 1). Right ureter: The main ureteral artery had its origin in common with the left ureteral artery, from the medial side of the right common iliac artery. After giving off two or three subperitoneal branches to the surrounding area it descended medial to and parallel with right common iliac artery for approximately 1 to 1.5 centimeters, and then crossed laterally to the ureter breaking up into a T-shaped branch, the descending branch of the T reaching the inferior part of the ureter where it anastomosed with an ascending branch from the inferior vesical artery. The ascending branch of the T anastomosed with a long branch from a supplemen-

tal ureteral artery which originated from the abdominal aorta. This ascending branch in addition to the anastomosis mentioned, coursed upward along the medial side of the ureter to within 1.5 centimeters of the kidney pelvis, where it anastomosed with a short branch from the renal artery. In addition to these two long arteries, which may be considered as the main blood supply of the ureter, there were two short branches from the renal artery which were found to descend over the renal pelvis and on to the ureter and a short fine branch from the hypogastric artery. The inferior portion of the ureter was additionally supplied by two short branches from the inferior vesical artery, and a free anastomosis was found between the superior, middle, and inferior vesical arteries in this region. All of the above primary arteries gave off smaller secondary branches which arborized and encircled the ureter, coursing upward and downward on its tunica muscularis anastomosing above and below with other similar arteries. Many fine branches were given off from each of these secondary arteries and were found to pierce the muscular coat.

Left ureter: The main ureteral artery was a long branch arising from the right common iliac artery in common with the main right ureteral artery; it crossed laterally and upward over the left common iliac artery to reach the ureter where it divided into an ascending, a posterior, and a descending branch. There were anastomoses between the subperitoneal branches of the right and left main ureteral arteries. The ascending and descending primary branches extended from the kidney pelvis to about 1.5 centimeters from the termination of the ureter. The posterior branch passed posterior to the ureter, then divided into ascending and descending branches which extended for only 1.5 centimeters. Two short branches arising from the branches of the renal artery descended on the ureter to anastomose by means of secondary branches with the ascending branches of the main ureteral artery and a short branch from the left internal spermatic artery. The terminal ureter was supplied by two short branches from the inferior vesical artery which came in to the lateral side of the ureter in contradistinction to the above named branches. These short arteries and their secondary branches anastomosed with the descending branch of the main ureteral artery and all gave off secondary branches similar to that described for the right ureter. These secondary branches formed a continuous plexus from the kidney pelvis to the bladder.

CASE 7. (Fig. 2.) Premature colored female 7½ months, death at 48 hours. Right ureter: The main ureteral artery arose from the anterior medial surface of the right common iliac artery 1 centimeter below the aortic bifurcation; coursing laterally to the ureter, it divided into the usual T-shaped ascending and descending primary longitudinal branches. A branch of the renal artery supplied the renal pelvis and the upper 1.5 centimeters of the ureter. This vessel also made anastomatic connection with a subperitoneal branch of the right ovarian artery. A branch from the hypogastric artery after arising from the medial side of this vessel, reached the medial side of the ureter where it divided into ascending and descending branches anastomosing above with the descending branches of the main ureteral artery and below with ureteral branches of the uterine and inferior vesical arteries. The usual secondary branches as described in Case 1 were found.

Left ureter: The main ureteral artery arose from the medial surface of the left common iliac artery and on reaching the ureter divided into ascending and descending branches. Its ascending branch anastomosed above with a short branch from the renal artery which descended over the pelvis to supply the upper 1 to 2 centimeters of the ureter. The descending vessel anastomosed with the ascending branch of the ureteral artery from the uterine artery. Descending twigs of the uterine branches anastomosed with ascending twigs of the middle hemorrhoidal, superior and inferior vesical arteries. Fine secondary branches to the walls of the ureter as described in Case 1 were present.

SUMMARY AND CONCLUSIONS

1. A review of the recent literature reveals that there are many who are called upon to treat carcinoma of the cervix who are now returning to surgical treatment, either alone or combined with radiation therapy.

2. Despite a remarkable reduction in the mortality rate of the Wertheim operation (notably Meigs) there still remains the vexing problem of ureteral fistula which often follows the Wertheim operation.

3. The general concensus that these ureteral fistulas are chiefly brought about by a disturbance of the blood supply of the ureter incurred during the operation.

4. With a view to studying the ureteral blood supply in relation to the operation, 14 ureters in 7 infants were dissected after arterial injection of a liquid latex mass.

5. The blood supply as found is described. The ureter is chiefly supplied by one or more fairly large arteries which may arise from the distal abdominal aorta, common iliac, or internal iliac arteries. These ureteral arteries may be single, double or triple. The long arteries, on reaching the ureter, divide in long ascending and descending branches which anastomose freely above with short branches from the renal and occasionally spermatic (ovarian) arteries and below with short branches from the vesical arteries and in the female the uter-

ine arteries. These longitudinal branches are loosely connected to the ureter and are contained within an adipose fibrous sheet. Secondary branches given off from these primary arteries arborize over the ureter for its entire length and anastomose freely with each other above and below and form a compact periureteral anastomosis from the renal pelvis to the bladder. A third set of arteries is given off from those vessels around the ureter and these in turn pierce the muscularis of the ureter to supply the wall.

6. Prophylaxis is the best treatment for this complication. In addition to a proficient knowledge of the normal and abnormal anatomy of the ureter, one must meticulously and gently dissect the ureter from its bed using every caution not only to preserve the periureteral arterial plexus but also carefully to dissect out and preserve the blood vessels to the ureter. These latter vessels are also to be avoided during pelvic lymphadenectomy. The avoidance of other contributing factors such as mass ligation, use of drains too close to the ureter, etc., are discussed. A survey of the nerve supply to the ureter leads us to offer a suggestion of hypogastric block or resection to increase the blood supply to the ureter as an additional prophylactic aid.

REFERENCES

1. Adams, T. W. West. J. Surg., 1943, 51: 305–320.
2. Anspach, B. M. Am. J. Obst., 1945, 50: 681–690.
3. Bland, B. P. Med. J. & Rec., 1928, 121: 389–392.
4. Bonney, V. Am. J. Obst., 1935, 30: 815–830.
5. Idem. J. Obst. Gyn. Brit. Empire, 1941, 48: 421–435.
6. Bushke, F., and Cantril, S. T. Am. J. Roentg., 1945, 54: 60–71.
7. Clark, J. G. Bull. Johns Hopkins Hosp., 1895, 6: 120–124.
8. Collins, C. G. Personal communication to the author.
9. Counseller, V. S. In discussion of Meigs, J. V. Surg. Gyn. Obst., 1945, 40: 542–559.
10. Cunningham, D. J. Text Book of Anatomy. P. 798. New York: William Wood and Company, 1903.
11. Feiner, D. Surg. Gyn. Obst., 1938, 66: 790–796.
12. Fitel, A. Zschr. Geburtsh. Gyn., 1895, 46: 296.
13. Freund. Cited by Jayle, M. F. Rev. fr. gyn. obst. 1943, 27: 53–68.
14. Frommolt, G. Münch. med. Wschr., 1932, 79: 1638.
15. Idem. Zschr. Geburtsh. Gyn., 1928, 93: 173–210.
16. Goodwin, A. Lancet, Lond., 1939, 1: 1142–1143.
17. Grey, H. Anatomy of the Human Body. P. 1237. Philadelphia and New York: Lea and Febiger, 1924.
18. Haller, A. V. Cited by Frommolt, G. Zsch. Geburtsh. Gyn., 1927, 91: 205.
19. Harper, W. F. Brit. J. Urol., 1942, 14: 63–72.
20. Hepburn, T. N. N. England J. M., 1934, 210: 1255–1257.
21. Kuntz, A. The Autonomic Nervous System. 3rd ed., Pp. 291–292. Philadelphia: Lea and Febiger, 1945.
22. Laroyenne, and Latarjet. Lyon méd., 1907, 109: 142.
23. Lenormant, C., and Leiboviei, R. Gyn. obst., Par., 1924, 10: 251.
24. Lieb, E. J. Tech. Methods, 1940, 20: 48–55.
25. Lynch, F. W. Am. J. Surg., 1940, 48: 249–254.
26. Idem. Tr. Am. Gyn. Soc., 1931, 56: 229–238.
27. Lynch, F. W., and Maxwell, A. F. Pelvic Neoplasms; Gynecologic and Obstetrical Monographs. Pp. 357–367; 377–412. New York: D. Appleton and Co., 1922.
28. Maguire, F. A. Australas. N. Zealand J. Surg., 1939–40, 9: 393–409.
29. Margorvicci. Cited by Harris, A. Am. J. Surg., 1930, 8: 801–809.
30. Martzloff, K. H. West. J. Surg., 1945, 53: 255.
31. McMurry, A. L. Texas J. M., 1935–36, 31: 318–320.
32. Meigs, J. V. Surg. Gyn. Obst., 1944, 78: 195–199.
33. Idem. Am. J. Obst., 1945, 49: 542–559.
34. Idem. N. England J. M., 1944, 230: 577–581; 607–612.
35. Idem. Surg. Gyn. Obst., 1947, 74: 249.
36. Mitchell, G. A. G. J. Anat., Lond., 1935–36, 70: 10–31.
37. Morton, D. C. West. J. Surg., 1944, 52: 1.
38. Idem. Am. J. Obst., 1945, 49: 19–31.
39. Narat, J. K., Loef, J. A., and Narat, M. Anat. Rec., 1936, 64: 155.
40. Nitch, Carl. Proc. R. Soc., Lond., 1932, 25: 1413–1426.
41. Ries, E. Zschr. Geburtsh. Gyn., 1895, 32: 266.
42. Robinson, B. Ann. Gyn. & Pediat. 1904, 17: 484–490.
43. Rumpf. Zschr. Geburtsh. Gyn., 1895, 33: 212.
44. Sampson, J. A. Bull. Johns Hopkins Hosp., 1904, 15: 39–46.
45. Ibid. 1904, 15: 123–134.
46. Schaeffer, J. P. Morris' Human Anatomy. P. 1437. Philadelphia: The Blakiston Company, 1942.
47. Schmitz, N. Am. J. Roentg., 1938, 40: 805–816.
48. Schlink, H. N., and Chapman, E. L. Med. J. Australia, 1938, 2: 74.
49. Skinner, F. H. Radiology, 1943, 40: 433–435.
50. Stoeckel. Cited by Frommolt (15).
51. Taussig, F. J. Am. J. Obst., 1934, 28: 650–667.
52. Ibid., 1943, 45: 733–748.
53. Idem. Am. J. Roentg., 1935, 34: 354–363.
54. Weaver, J. D. Texas J. M., 1945, 41: 191–195.
55. Weibel, W. Zbl. Gyn., 1932, 56: 2637.
56. Wertheim, E. Am. J. Obst., 1912, 46: 168–232.
57. Wharton, L. R. J. Urol., Balt., 1932, 639–673.

HYPERTROPHIC PYLORIC STENOSIS

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PYLORIC stenosis is the most common condition requiring surgical treatment in the first few months of life (12). The diagnosis is being made more and more frequently. Ladd (12) states that the operative attack on pyloric stenosis marks one of the greatest advances in abdominal surgery in the last 20 years.

Two hundred and forty-eight cases of pyloric stenosis have been admitted to Milwaukee Children's Hospital between June 1924 and May 1947. The Fredet-Rammstedt pyloromyotomy was done on 232 of these and 15 were not operated upon. Sixteen deaths have occurred in this series, 9 of which were postoperative deaths. The 7 other cases were treated medically.

There has been no death during the past 10 years, during which time diagnoses were made and operations performed in 172 infants. We believe that we can point out several reasons responsible for this drop in mortality rate.

INCIDENCE

The majority of cases of pyloric stenosis occur in males. Our series show a preponderance of 6.5 males to 1 female, or 86 per cent in males. Ladd reported 85 per cent; Fredeen 78 per cent.

Our records show that 1 in 213 children admitted to Milwaukee Children's Hospital had pyloric stenosis. Cranmer estimates that 1 in 400 male infants is affected. Wallgren reviewed the records of all children born in Göteborg, Sweden, from 1934 to 1940, and found that among 25,642 children born, 102, or 0.4 per cent, developed pyloric stenosis. This is 1 in 250 births. On studying further, he found the incidence to be 1 in 770 girls born and 1 in 154 boys born. These figures would not necessarily be significant for this country since it is well known that the disease is common in some races, that it is rare in others, and that we represent a mixture of all the races.

Wallgren called attention to Eckstein's report that he observed only 2 children with pyloric stenosis among 50,000 patients treated in the out-patient department for children's diseases at Ankara, Turkey, and that the parents of these children were foreign born; also, that a pediatrically trained medical missionary found only one case during many years in the Belgian Congo, and that this patient was of French parentage.

There were no negroes in our series. Fredeen reports 1 negro female in 32 cases at the University of Kansas. Romano reports 30 per cent in negroes from the Charity Hospital in New Orleans.

It has frequently been reported that the majority of cases are found in the first born of a family. Our figures bear this out. First born constituted 43 per cent of our cases, second born 21 per cent, third born 16 per cent, and fourth born 5 per cent. One case was the 12th child in the family. None of the first 11 children had been affected.

About half of our cases were breast fed and the other half were artificially fed. We can find no justification of some claims that pyloric stenosis occurs most often in artificially fed babies.

Seventy per cent of the patients in this series were between the ages of 3 and 6 weeks. The youngest was 10 days old and the oldest was 7 months. MacHaffie of Canada reports an infant that was operated on 34 hours after birth. Reports have been numerous of pyloric stenosis in adults (2, 11). The majority of these are diagnosed either in the specimen removed during a subtotal gastric resection for suspected carcinoma, or at the autopsy table.

Our series contained 9 instances in which more than one member of the family was affected with pyloric stenosis. In one family there were 3 cases, 2 boys and a girl. In

From the Surgical Service of the Milwaukee Children's Hospital.

another family 2 boys and their cousin developed the disease. There were 3 families in which 2 brothers were affected, and 3 in which a brother and sister were affected. In 1 instance, a boy and his father were both operated upon for pyloric stenosis. One of our series had a cousin who died of pyloric stenosis.

There were 7 cases in which one of a set of twins developed the disease. In 5 of these, the second twin was unaffected, and in the 2 others the second twin was a feeding problem or had pylorospasm. We have been unable to prove that any of these were identical twins.

PATHOLOGY

The gross appearance of the pyloric tumor is quite characteristic. It is a firm, pale, bluish-white, olive-shaped mass about 2.5 centimeters long and about 1.5 centimeters in diameter. The serosal covering is smooth and glistening, containing blood vessels that branch out from the peritoneal reflection and end just short of a superior longitudinal avascular area.

Biopsy specimens were taken of the tumor at the time of operation in 72 cases during the past 5 years. These were studied microscopically, and the tumors were found to be composed of hypertrophied smooth muscle fibers arranged in whorls and bundles much in the same manner as a leiomyoma of the uterus. The individual smooth muscle fibers revealed some hydropic change. There was considerable extracellular edema and in most instances fibrosis. Some sections revealed scattered infiltrations of lymphocytes.

It is our impression that this is not only a hypertrophy of the circular layer of smooth muscle fibers that make up the pyloric tumor, as is indicated in so many reports, but also a hypertrophy of the longitudinal fibers of smooth muscle that extend down from the stomach and dip into the pyloric sphincter, giving it the microscopic appearance of crisscrossing of fibers and making it impossible to distinguish the longitudinal from the circular fibers.

SYMPTOMS

The cardinal symptoms of pyloric stenosis are (1) projectile vomiting, (2) failure to gain weight, (3) constipation, (4) visible peristaltic waves, (5) palpable pyloric tumor.

1. *Projectile vomiting.* In the average case, vomiting usually began during the third week of life, as an infrequent regurgitation and became progressively more frequent and more intense until about the fifth week when the vomiting became projectile in nature and the patient was brought to the hospital. There was usually a history of numerous formula changes, none of which agreed with the patient or stopped the vomiting. The parents described the vomiting as "explosive" and "coming through the mouth and nose."

In none of our cases was there any bile in the vomitus.

Seventy seven per cent of our cases had a history of projectile vomiting on entrance to the hospital. A few of the remaining developed projectile vomiting in the hospital, and 22 per cent did not have "forceful" vomiting at any time.

2. *Failure to gain weight.* One of the earliest symptoms was the failure to gain weight. As vomiting continued, the patients not only failed to gain but began to lose weight. Of our cases, 62 per cent were below birth weight on admittance to the hospital; the rest showed substantial weight gains above birth weight. Entrance physical examination revealed 80 per cent to be undernourished and markedly dehydrated. Only 20 per cent of the infants were found to be well nourished and well hydrated.

3. *Scanty stools.* In 75 per cent of our cases the patients had a history of scanty dark starvation stools which Ladd points out are not constipation stools but rather obstipation resulting in less and less fecal residue, a condition due to mechanical blockage at the pylorus. Eight per cent entered the hospital with diarrhea. These infants invariably were markedly dehydrated, malnourished, and in poor physical condition.

4. *Visible peristaltic waves.* Peristaltic waves were noted in 83 per cent of our cases. Close study of the hospital records revealed that peristaltic waves were almost always seen when the examiner took the trouble to give the patient some water to drink and waited for the waves to form.

5. *Palpable tumor.* The pyloric tumor is present in every true case of pyloric stenosis.

At times it is very difficult or impossible to feel.

Ladd, Ware, and Pickett felt the tumor in over 98 per cent of cases. Brown of Nebraska felt the tumor in 44 per cent of cases. Our records show that a tumor was felt in 63 per cent of cases. However, several individuals with considerable experience were able to feel about 90 per cent in the cases with which they were associated.

DIAGNOSIS

Projectile vomiting is usually the first symptom to call the examiner's attention to this condition. It should stimulate him to inquire into the bowel habits and weight gain of the patient and to seek the peristaltic waves and palpate the pyloric tumor. Occasionally the mother will volunteer the information that she has seen "knots going across the stomach," but usually the examiner must stimulate the production of the peristaltic waves himself. This is easily done by placing the undressed patient between the examiner and a window or light, and giving the patient some water to drink. The peristaltic waves begin in the left upper quadrant and progress diagonally down and across the abdomen above the umbilicus. Usually two waves the size of a half golf ball are evident with a depression between them. The waves cast a shadow into the depression as they move across the abdomen from left to right.

Peristaltic waves are seen in other conditions, such as pylorospasm, and therefore are not diagnostic without other accompanying symptoms. Peristaltic waves running from right to left are indicative of large bowel pathology, and may be confused with the gastric peristaltic waves which are found in pyloric stenosis.

A palpable pyloric tumor is pathognomonic of pyloric stenosis, and is therefore the most important finding for establishing the diagnosis. Occasionally the tumor is easily felt, but usually considerable dexterity and experience are required to palpate even a markedly enlarged pylorus, since the majority of patients are hypertonic and crying when first seen in the examining room. Our records show very plainly that the highest percentage of tumors are felt by those who have the greatest experience and those who make their examination under the proper conditions.

The tumor is most easily felt in the manner described by Seeger.

The operator is seated at the right of the examining table and the right hand is used to palpate the abdomen while the left hand is placed beneath the patient to give counter pressure from below. Usually the olive-shaped tumor is felt near the midline in the right upper quadrant just beneath the edge of the rectus muscle. It is quite mobile and can sometimes be rolled against the prominent spine. Often its position can be determined by watching the point where the peristaltic waves end.

A palpable tumor is positive evidence of pyloric stenosis. Failure to palpate a tumor is not conclusive proof to the contrary (10).

During the past few years we have become more and more aware that roentgenologic examination is one of the most important procedures available in the diagnosis of pyloric stenosis. We agree that if pyloric tumors were 100 per cent palpable there would be little value in subjecting the patient to this procedure, but in our series the tumor was palpable in only 63 per cent of cases. Series reported in the literature record the tumor as being variously palpable, from 24 per cent (17) to 98 per cent (13).

In reviewing the records of 187 cases of pylorospasm seen at Milwaukee Children's Hospital between 1924 and 1947, 6 cases were found in which examiners reported feeling the pyloric tumor. In all of these, subsequent roentgenologic examination was done and reported negative for pyloric stenosis. In spite of the negative x-ray report, 1 patient was operated upon and a normal pylorus was found at operation.

In 3 other cases, examiners reported feeling the pyloric tumor, but no x-ray examinations were made before operation. In all of these, a normal pylorus was found during operation. One of the 3 later died of septicemia. It is evident, then, that our only pathognomonic finding is not 100 per cent reliable.

When properly performed, roentgen examination is almost 100 per cent reliable. The

pyloric tumor containing barium casts a typical shadow of the stenosed pyloric canal, which is funnel-shaped at its entrance and long and narrow through its lumen. This has been described by Hefke as a "prepyloric narrowing" and the "string sign." Delayed opening time and gastric retention of barium are helpful in making the diagnosis, but the "prepyloric narrowing" and the "string sign" give an exact picture of the stenosed pyloric canal, which is not simulated by any other condition.

Many authorities object to the use of roentgen examination because of the possibility of aspiration of barium or because of the difficulties that the barium might cause at operation. These same authorities recommend that, "full formula feedings be maintained during the preoperative period regardless of the vomiting."

We do not believe that the danger of aspiration of barium is any greater than the danger of aspirating vomitus from the periodic full formula feedings recommended during the preoperative period.

In all of our cases, the stomach is lavaged after the roentgen procedure and before operation and there has been no difficulty from any residual barium in the stomach.

The x-ray procedure is carried out in the following manner:

The patient is given no food for 6 hours to insure that the stomach is empty, then the patient is given 2 ounces of formula-barium mixture and the patient is observed under the fluoroscope. Roentgenograms are taken at 5 minutes and 30 minutes, in positions determined by fluoroscopy to show the best view of the pyloric canal. This is invariably a right oblique position. If the canal is well visualized in the 30 minute film, no more films are taken, otherwise subsequent 1 and 2 hour films are taken until a good view of the canal is obtained.

TREATMENT

The evolution in the surgical treatment of pyloric stenosis is very interesting and its beginning dates back to 1892 when Cordua of Hamburg, Germany, performed the first surgical procedure, a jejunostomy, with an unsuccessful outcome (8).

Four methods of surgical treatment have been in use (1). The first and most unsuccessful was the Loreta divulsion of the pylorus in which an incision was made into the anterior wall of the stomach and graduated sounds were passed into the stomach and through the pylorus stretching its lumen. Usually the pyloric mass broke rather than stretched, and the patient died of peritonitis.

The second operation was a simple pyloroplasty advocated by Dent in 1902. A longitudinal incision was made through the tumor extending from the stomach to the duodenum, cutting through all layers including the mucosa. This longitudinal incision was then transformed into a transverse incision by bringing the ends together with sutures in the manner of the Heineke-Mikulicz operation. The mortality rate, however, was too high. Surgeons began doing gastroenterostomy with which many were familiar. Even so, the mortality rate was very high.

In 1906, Nicoll began doing a partial pyloroplasty in which only the muscle and not the mucosa was incised. He made a V-shaped incision through the tumor at right angles to the long axis and by converting it into a Y, increased the diameter of the lumen. This was the first of the submucous pyloroplasty operations.

In 1908, Fredet made a longitudinal incision through the muscle layer, not opening the mucosa, and converted it into a transverse incision in order to increase the lumen diameter, by bringing the two ends together with sutures.

In 1911, Rammstedt was performing the Fredet submucous pyloroplasty and found that he could not get the ends together because his sutures tore out of the edematous hyperplastic tumor, so he sutured the omentum over the incision and closed the abdomen. The patient got along very well. In 1912, during another operation, he incised the pyloric muscle and left the defect uncovered in the manner in which the operation is performed today. The patient made an uneventful recovery. This procedure is essentially the same operation that is universally carried out today and is known as the Fredet-Rammstedt pyloromyotomy.

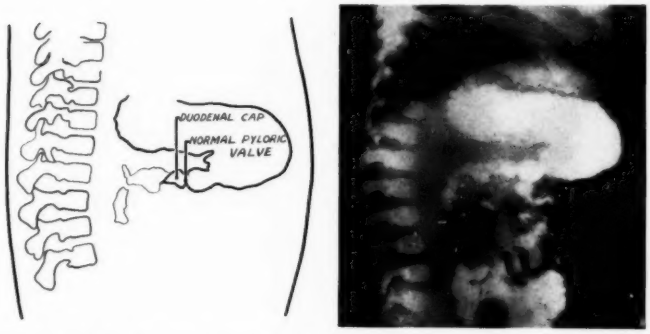

Fig. 1. a, left, Diagram of normal pylorus. b, Roentgenogram of normal pylorus.

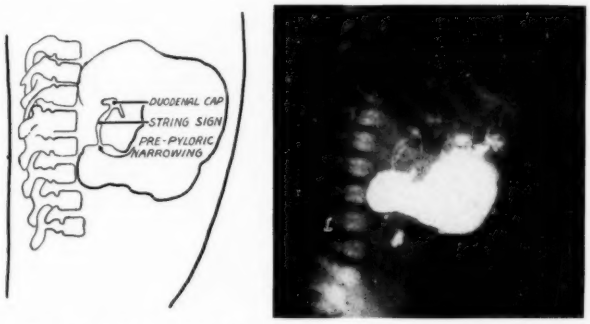

Fig. 2. a, left, Diagram of case of hypertrophic pyloric stenosis. b, Roentgenogram of same case showing hypertrophic pyloric stenosis.

PREOPERATIVE TREATMENT

Probably the greatest aid in the reduction of operative mortality rated during the past 10 years has been early diagnosis and adequate preoperative care.

Pyloric stenosis is no longer considered an emergency. Operation is frequently postponed 24 to 48 hours in a particularly dehydrated individual, while fluids are given to hydrate the patient and to re-establish electrolyte balance. Usually 60 to 100 cubic centimeters of Ringer's solution is given subcutaneously every 6 to 8 hours depending upon the degree of dehydration which is present and upon the size of the patient.

Some writers have used parenteral amino acids preoperatively in particularly malnourished and dehydrated patients either intravenously or subcutaneously, and have reported gratifying results. A few years ago the proper diagnosis occasionally was not made until the patient was marasmic. These patients were given preoperative transfusions together with parenteral fluids. During the past few years, it has been routine at Milwaukee Children's Hospital to give the patient a transfusion before leaving the operating room, 10 cubic centimeters per pound body weight of whole blood being given by the multiple syringe method. This transfusion corrects the depleted serum protein and brings the lowered red blood cell count and hemoglobin values up to a satisfactory level, giving the patient an added boost to carry him through the immediate postoperative period until he can care for his own nutritional requirements. We believe that this procedure has been very instrumental in lessening postoperative complications and at the same time in making for an easier convalescence.

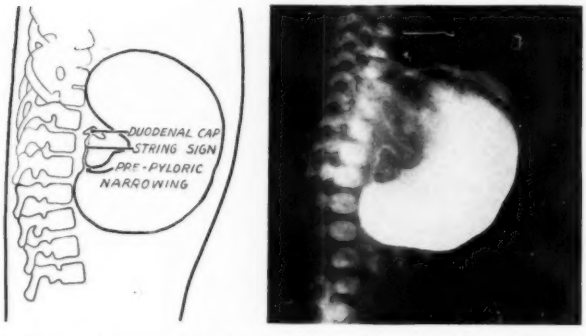

Fig. 3. a, left, Diagram of another case of hypertrophic pyloric stenosis. b, Roentgenogram of same case.

OPERATION

It is almost universally agreed that the Fredet-Rammstedt pyloromyotomy is the operation of choice in the surgical treatment of pyloric stenosis. This operation was used in all of the cases which were surgically treated in this series.

The correct type of abdominal incision to use is still a matter of discussion. Three types of incision were most generally used in this series. Many of the earlier surgeons made no record of the type of incision used, so no accurate account can be given. The earliest incision to be used was the right rectus incision which remained popular until Robertson described the gridiron incision in 1940. For about 3 years after that, various adaptations of the gridiron incision were used. The most popular of these was Meredith's adaptation in which a regular right rectus incision was used, but in which the posterior rectus sheath and peritoneum was opened transversely. In 1943, the majority of surgeons reverted back to the right rectus incision but made it high just beneath the rib margin in order to utilize the liver as a stop-plug to block the intestines from extruding through the wound. After closure of the wound, the right lower margin of the liver slides back into place behind the incision and prevents the intra-abdominal pressure from being exerted directly against the incision. This type of incision is most popular today and it has been found that in no case has wound dehiscence or incisional hernias resulted.

The pyloric tumor is usually quite mobile and is easily brought into the abdominal opening. A longitudinal incision is made through the serosa and slightly into the hypertrophied muscle at the superior border which is usually the most avascular area while the assistant holds the duodenum and stomach, rotating the pyloric tumor downward to present the superior avascular area. No attempt is made to cut entirely through the muscle, but only through the serosal layer from the stomach to the duodenum separating only the most superficial muscle fibers. The closed points of a small artery forceps are inserted into the incision and spread, breaking through the muscle fibers which make up the tumor. This is carefully carried out until the underlying mucosa is freed of the surrounding fibers and bulges through the incision. At the stomach end of the tumor the muscle fibers gradually blend into those of the stomach, but at the duodenal end the muscle fibers end bluntly, extending into the duodenal lumen in the manner of the cervix into the vagina. It is here that great care must be exercised in separating the muscle fibers, since the closely investing mucosa of the duodenum is easily torn in the process, and if this accident is not detected the resultant leaking will cause peritonitis.

When the incision is made in the avascular area, very little bleeding results. The small amount of oozing can be controlled with warm moist packs. Large bleeders are difficult to ligate in the edematous tumor and occasionally a stitch tie is required. In some of the

earliest operations, omentum was sutured over the defect in the pylorus, but this is seldom done anymore.

After the pylorus is returned to the abdomen, the wall is closed in layers.

The anesthetic of choice in this series has been open drop ether. Procaine infiltration anesthesia was formerly used but has been almost entirely abandoned during the past few years.

POSTOPERATIVE TREATMENT

Considerable controversy exists concerning the proper postoperative treatment of pyloric stenosis. Some authorities advocate immediate full formula feedings, while others give nothing by mouth during the first 24 hours after operation.

Faber and Davis of Stanford gave 10 infants a teaspoonful of barium sulfate suspended in 1 ounce of water from 1 to 5 hours after the standard Fredet-Rammstedt pyloromyotomy. Periodic examinations with fluoroscopy and x-rays were made to determine the rate and extent of emptying of the stomach immediately following operation. They found that in the average case the evacuation of the barium from the stomach did not begin for over 8 hours and that evacuation was not complete for 24 hours. Basing their argument on these findings, they do not believe that early and frequent administration of food and water during the immediate 24 hour postoperative period is desirable.

Our routine postoperative feeding schedule has been a compromise between these two extremes.

The patient is given ½ dram of water 1 hour after operation and the water is increased by ½ dram every 2 hours. Two hours after operation the patient is given ½ dram of formula and this is given every 2 hours with an increase of ½ dram for each feeding until the patient has received eight feedings of water and eight feedings of formula. The patient is not awakened during the night for feedings. On the second day ½ ounce of formula is given every hour and the water is discontinued. On the third day 1 ounce of formula is given every 2 hours. On the fourth day 2 ounces of formula are given every 2 hours. On the fifth day the normal feeding schedule is resumed.

If the patient persists in vomiting, the feedings are reverted back to the last change.

In our series, 23 per cent had a slight amount of postoperative vomiting not requiring a decrease in formula feedings; 5 per cent required changes in formula feedings, and in 3 cases reoperation was necessary.

It was seldom necessary to give parenteral fluids after operation because of severe vomiting.

The skin sutures were usually removed on the seventh or eighth day, and the patient was discharged on the ninth or tenth day.

TABLE I.—COMPLICATIONS

	1924 to 1927	1928 to 1931	1932 to 1935	1936 to 1939	1940 to 1943	1944 to 1947	Total %
Accidental duodenal perforation	2	2	3	3	7	3	9
Wound infections	4	2	2	2	2	0	5
Dehiscence of wound after infection	2*	1	0	0	1	0	1.6
Bronchopneumonia	1*	3†	0	0	1	2	3
Otitis media	3	1	0	0	1	1	2.5
Recurrences	0	0	1*	1*	1	0	1.3
Hernia of wound	0	0	0	0	1	1	0.8
Hemorrhage	0	0	0	0	0	1	0.4

*One died
†Three died

Accidental perforation of the mucosa. The most frequent complication in our series, and the one most commonly warned against in the literature is accidental perforation of the duodenal mucosa. This complication occurred 21 times in our series of cases. Ladd (12) reported 23 perforations in his series of 1,000 cases.

It should be routine for every operator to test for possible perforation by squeezing the stomach and duodenum together and watching for the escape of gas bubbles.

Wound infection. Wound infection was the second most common complication, occurring in 12 cases. Four of these resulted in dehiscence of the incision and 1 of the 4 died of a resulting peritonitis.

Upper respiratory infection was a complication in 12 cases. Half of these patients developed otitis media and the remaining suffered with nasopharyngitis.

TABLE II.—OPERATIVE MORTALITY—232 PATIENTS OPERATED UPON WITH 9 DEATHS—3.8 PER CENT MORTALITY

1935—Peritonitis (recurrence; reoperated upon) (autopsy)
1932—Peritonitis (recurrence; reoperated upon) (autopsy)
1931—Bronchopneumonia (no autopsy)
1929—Inanition—dehydration (autopsy)
1928—Bronchopneumonia (autopsy)
1928—Bronchopneumonia (autopsy)
1927—Peritonitis (wound dehiscence) (autopsy)
1926—Peritonitis (autopsy)
1925—Bronchopneumonia (no autopsy)

TABLE III.—MEDICALLY TREATED MORTALITY—15 PATIENTS TREATED MEDICALLY WITH 7 DEATHS—46.6 PER CENT MORTALITY

1937—Pyloric obstruction—inanition
1934—Pyloric obstruction—inanition
1931—Pyloric obstruction—bronchopneumonia
1929—Pyloric obstruction—malnutrition
1927—Pyloric obstruction—bronchopneumonia
1927—Pyloric obstruction—bronchopneumonia
1926—Pyloric obstruction—malnutrition
(All were proved by autopsy)

Bronchopneumonia. Bronchopneumonia was a complication in 7 cases. Four of these infants died.

Postoperative vomiting. Severe vomiting continued postoperatively in 12 cases and had to be treated with atropine. In 3 of these a diagnosis of recurrence was made and the infants were operated upon a second time to separate the muscle fibers which had been incompletely separated during the first operation. Two of the 3 died of peritonitis. The duodenum was accidently perforated in the remaining case during the second operation, but the accident was noted and the defect was closed with a mattress suture.

Recurrences. There were 5 cases of recurrence in our series. Three of these received both their first and second operation here. The 2 remaining were operated upon elsewhere the first time and came to Milwaukee Children's Hospital for their second operation. It is possible that some of our patients were reoperated upon elsewhere because of recurrences, but no such case has been brought to our attention.

Diarrhea. Severe diarrhea complicated 4 cases, resulting in prolonged hospital stay, but not ending in any fatalities.

Hernia. Postoperative abdominal hernias occurred in 2 cases. In both instances low right rectus incisions had been used.

Hemorrhage. There was 1 case of intra-abdominal bleeding in which hemoglobin dropped to 3.5 grams. Transfusions were given and the bleeding stopped spontaneously. The remaining convalescence was uneventful.

MORTALITY—TABLES II AND III

Of the 247 patients treated for pyloric stenosis at Milwaukee Children's Hospital, 16 died, making a mortality rate of 6.4 per cent.

Two hundred and thirty-two were treated surgically with 9 deaths, giving an operative mortality rate of 3.8 per cent.

Of the 15 remaining patients treated medically, 7 died with a mortality rate of 46.6 per cent.

There has been no death during the past 10 years and 172 patients have been operated on consecutively without a fatality.

This compares favorably with large series reported in the literature.

Ladd (13) reporting 1000 cases had an overall operative mortality rate of 4 per cent and had operated upon 225 consecutive patients without a death.

SUMMARY

1. The hospital records of 248 cases of pyloric stenosis were reviewed.

2. There were 9 instances in which more than one member of a family was affected and 7 instances in which one of a set of twins had the disease.

3. Biopsies of the pyloric tumor taken in 72 cases during operation, and microscopic study revealed that the longitudinal as well as the circular smooth muscle fibers were involved.

4. Peristaltic waves were visible in 83 per cent of cases and tumors were palpable in 63 per cent of cases.

5. Roentgenologic examination, too little used, is a valuable diagnostic procedure, since physical examination is not 100 per cent reliable.

6. Early diagnosis and adequate preoperative care are responsible for the reduction in mortality rate.

7. Routine blood transfusions at the time of operation make for a smoother convalescence and a reduction in postoperative complications.

8. There has been no death during the past 10 years and 172 consecutive patients have been operated on without a fatality.

REFERENCES

1. Abt, Isaac. Pediatrics, Vol. 3, 452. Philadelphia: W. B. Saunders Co., 1924.
2. Berk, J. E., and Dunlap, H. J. Ann. Surg., 1944, 119: 124.
3. Brown, A. Nebraska M. J., 1938, 23: 128.
4. Cranmer, R. R. Minnesota M., 1941, 24: 688.
5. Eckstein, A. Jahrb. Kinderh., 1940, 155: 16.
6. Faber, H. K., and Davis, J. H. J. Am. M. Ass., 1940, 114: 847.
7. Fredeen, R. C., Orr, J. G., and Neff, F. C. J. Kansas M. Soc., 1939, 40: 45.
8. Gius, J. A. West. J. Surg., 1944, 52: 209.
9. Hefke, H. W. Radiology, 1944, 43: 267.
10. Johns, F. S., and Stone, J. B. Virginia M. Month., 1945, 72: 151.
11. Kestel, J. L. J. Iowa M. Soc., 1938, 28: 147.
12. Ladd, W. E., and Gross, R. E. Abdominal Surgery of Infancy and Childhood. Philadelphia: W. B. Saunders Co., 1941, Chap. 1.
13. Ladd, W. E., Ware, P. F., and Pickett, L. K. J. Am. M. Ass., 1946, 131: 647.
14. MacHaffie, L. P. Canad. M. Ass. J., 1927, 17: 946.
15. Meredith, E. W. Pennsylvania M. J., 1940, 43: 1686.
16. Robertson, D. E. Ann. Surg., 1940, 112:687.
17. Romano, S. A., and McFetridge, E. M. Internat. S. Dig., 1938, 25: 131.
18. Seeger, S. J. Surg. Gyn. Obst., 1939, 68: 1074.
19. Wallace, H. L., and Wevill, L. B. Brit. M. J., 1934, 1: 3834.
20. Wallgren, A. Am. J. Dis. Child., 1941, 62: 751.

INFRARED PHOTOGRAPHIC STUDY OF THE SUPERFICIAL VEINS OF THE THORAX IN RELATION TO BREAST TUMORS

A Preliminary Report

LEO C. MASSOPUST, Milwaukee, Wisconsin

NORMAL patterns of the superficial veins in the living human body have been photographed by infrared photography and are recorded in the medical literature. In previous publications it has been shown also that infrared photography is of value in recording the changes in the superficial venous pattern caused by any condition which affects the circulation.

PURPOSE

This study is based on a survey of 100 cases of breast complaints entering the dispensary of the Marquette University School of Medicine from the Cancer Detection Center of the Medical Society of Milwaukee County. The object was to ascertain: (1) whether a tumor within the breast would alter or disturb the pattern of the superficial veins of the thorax; (2) whether the infrared photograph might serve as an aid in determining whether the tumor was malignant or benign; and (3) whether the infrared photographic method might be of any practical assistance in the diagnosis of cancer of the breast.

In approaching the problem it might be well to offer first of all some clue as to the nature of the types of venous patterns found in the normal human chest. For purposes of simplicity, these venous patterns are referred to as infrared phlebograms and are classified into two types, longitudinal (Figs. 1 and 3) and transverse (Figs. 2 and 4). The *longitudinal* type radiates in a fan-like pattern downward and laterally into the breasts from the point where the anterior jugular vein connects with the arch of the jugular vein (Fig. 1,*A*). This pattern seems to be associated with the pendulous type of breast. The *transverse* type pattern radiates laterally in both directions from the pectoral venus plexus (Fig. 2, *B*) toward the axillary and costoaxillary regions. The transverse type pattern is usually found in the normal, youthful type of breast.

From the Department of Anatomy, Marquette University School of Medicine.

MATERIALS AND METHODS

Photographic materials, methods, and various applications of infrared photography have been discussed in previous publications. Any camera may be used. The image is focused with a Wratten No. 25 filter over the lens; this filter is then replaced with a Wratten No. 87 filter and the diaphragm is closed to the f. 32 stop. The photograph is made on Eastman infrared sensitive film or plates. The back of the camera is tilted slightly upward to bring the plane of the film parallel with the plane formed by the protruding breasts. This is particularly necessary if the breasts are large.

The most convenient and efficient source of illumination for use with infrared sensitive emulsions is the incandescent tungsten filament lamp. In Figures 1 to 16 the patient is illuminated from each side by a vertical bank of five 100 watt lamps directed toward the chest, and two 500 watt lamps directed toward the chest at an angle of about 45 degrees, 36 inches away from the patient. It is important to strive for flat illumination, for very slight differences of light intensity are recorded with extreme contrast on the infrared sensitive emulsion. Movement is controlled by asking the patient to hold her breath. The exposure time is ½ second. Infrared sensitive emulsions are loaded and processed in total darkness.

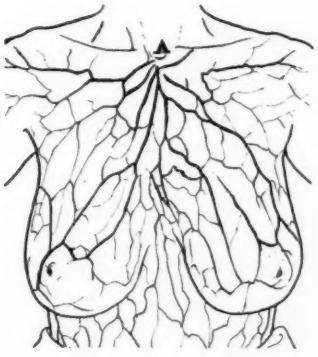

Fig. 1.

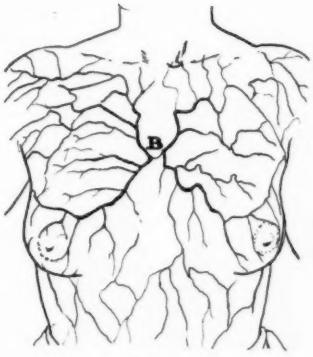

Fig. 2.

Fig. 3.

Fig. 4.

CASE REPORTS

Mrs. B., 40 years of age, weight 105 pounds, with one child, 13 years old, entered clinic with no complaint, but for checkup only. Infrared phlebogram revealed a symmetrical pattern of equal photographic density of the superficial veins in both mammary glands and pectoral regions; transverse type (Fig. 5).

Mrs. D., 35 years of age, weight 131 pounds, no children, had fibrocystic disease of both breasts. Infrared phlebogram revealed an undisturbed symmetrical pattern of the superficial veins in both mammary glands and pectoral regions. The veins just above the areola in each breast border on varicosities; longitudinal type (Fig. 6).

Mrs. O. D., 37 years of age, weight 115 pounds, 2 children, had a tumor in right breast. Infrared phlebogram demonstrated an undisturbed symmetrical pattern of equal photographic density of the superficial veins in both mammary glands and pectoral regions. The pattern is revealed with unusual clarity; longitudinal type (Fig. 7). Pathologic examination revealed fibrocystic disease of the breast.

Mrs. J., 53 years of age, weight 138 pounds, 2 children, had a lump in the left breast. Infrared phlebogram shows the superficial veins in the left mammary gland to be quite conspicuous, while those in the right breast are only faintly visible. There is also some engorgement of the veins which extend transversely across the left breast, just above the nipple; longitudinal type (Fig. 8). Pathologic examination revealed adenocarcinoma, scirrhous type, grade III, with involvement of axillary nodes.

Mrs. B., 29 years of age, weight 168 pounds, 5 children, had a lump in right breast. Infrared phlebogram showed the superficial veins in both mammary glands and pectoral regions to be undisturbed, symmetrical in pattern and of equal density; longitudinal type (Fig. 9). Pathologic examination revealed adenofibrosis of the breast with a solitary cyst.

Mrs. R., 50 years of age, weight 206 pounds, 3 children, had a painful lump in the left breast. Infrared phlebogram showed the venous pattern in the left mammary gland to be irregular in pattern and density, with engorgement of a vein in the pectoral plexus. A retracted area was present in the left breast just lateral to the nipple; this breast was distorted in shape. Slight changes in the shape of the

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

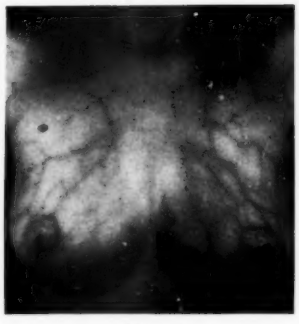

Fig. 11.

breast are difficult to see upon visual inspection; the photograph, however, brings both breasts within the focus of the eyes; thus revealing these slight distortions quite clearly. The regularity of the venous pattern and density in the right breast contrasts greatly with those in the left (Fig. 10). Pathologic examination revealed scirrhous carcinoma with metastasis to lymph nodes; longitudinal type.

Mrs. C., 35 years of age, weight 126 pounds, 1 child, had a lump in the left breast. Infrared phlebogram showed the superficial veins in both mammary glands and pectoral regions to be undisturbed and of equal distribution and density (Fig. 11). Pathologic examination revealed fibrocystic changes within a previous adenoma, with no evidence of malignancy. Transverse type.

Fig. 12.

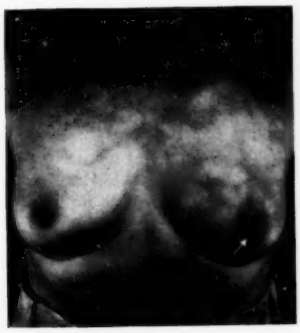

Fig. 13.

Fig. 14.

Fig. 15a.

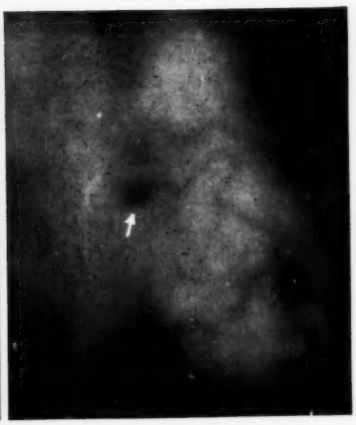

Fig. 15b.

Fig. 16a.

Fig. 16b.

Mrs. H. R., 55 years of age, weight 151 pounds, no children, had an advanced carcinoma of the right mammary gland (Fig. 12).

Mrs. K., 41 years of age, weight 142 pounds, 1 child, had a painful lump in the left breast. Infrared phlebogram showed the superficial veins in the left breast more conspicuously than those in the right (Fig. 13). They are indefinite in outline and are somewhat enlarged. Note the wrinkle at the arrow. Unilateral wrinkling just below the nipple has been observed in the photographs in a number of cases which proved to be malignant. It is probably caused by a lesion in the breast which produces a beginning retraction of the nipple. This slight wrinkling can be overlooked easily at visual inspection, but is revealed very clearly in the photograph. Pathologic examination revealed a medullary carcinoma located deep in the left breast, with some metastatic nodules present within the breast tissue.

Mrs. B., 49 years of age, weight 120 pounds, no children, noticed a lump in the right breast a year ago, which has increased in size. Infrared phlebogram shows the right breast to be distorted. There is a lump in the upper lateral quadrant, and areas of unequal density below and above the nipple (Fig. 14). Note the three shallow wrinkles below the right nipple, indicating greater retraction of the nipple than that seen in Figure 13. Pathologic examination revealed a scirrhous carcinoma with regional lymph gland metastasis.

Mrs. V. B., 35 years of age, weight 116 pounds, no children, was operated upon 6 years previously for cyst in the right mammary gland posteriorly. A lump recurred, slightly anterior to the old scar. There is drainage through the nipple, with constant pain. Infrared phlebogram, anterior view (Fig. 15a), shows that the superficial veins in the right mammary gland are more conspicuous than those in the left. The outline of a lump can be seen in the axillary region on the right side. In the lateral view (Fig. 15b) the patient's arm is raised over her head, thus flattening the surface in the axillary region. Note the area of increased density, indicated by the arrow, just anterior to the scar of the previous operation. This area of density in the infrared photograph could not be seen upon inspection. There is a confluence of the veins toward this dark area. Pathologic examination revealed an adenocarcinoma, grade III, without demonstrable axillary involvement

This patient, a woman 63 years of age, weight 151 pounds, with 1 child, had a tumor mass with superficial lesion in right mammary gland. Medullary type of carcinoma (Figs. 16a and 16b).

CONCLUSIONS

Of the 100 cases of breast complaints studied, 65 were tumors. Following the study of about 75 cases of breast tumors, certain standards in the interpretation of the infrared phlebogram were established. In at least 6 patients brought in subsequently the phlebogram did not agree with the clinical diagnosis. In all of these cases, however, the pathologic diagnosis confirmed the findings in the infrared phlebogram.

As a result of this limited study by infrared phlebogram, the tentative conclusions are made:

1. In some breast tumors the appearance and pattern of the superficial veins of the thorax are altered.

2. The infrared photograph reveals information difficult to obtain upon unaided visual inspection, and in some cases impossible to obtain in any way other than by an infrared phlebogram.

3. Further study of many more benign and malignant tumors might indicate that the infrared phlebogram may serve as an additional adjunct in the detection and classification of tumors of the breast.

Realizing that the evaluation of the infrared phlebogram in the study of breast tumors can be established only by its general use, this laboratory is prepared to co-operate with others in the use of this simple procedure.

REFERENCES

1. Massopust, L. C. Radiog. & Clin. Phot., 1934, 10: 2–6.
2. Idem. Anat. Record, 1934, 61: 71–79.
3. Idem. J. Biol. Phot. Ass., 1936, 5: 20–24.
4. Idem. Surg. Gyn. Obst., 1936, 63: 86–89.
5. Idem. Arch. Path., 1937, 23: 67–70.
6. Idem. In Glasser, O., Medical Physics, pp. 942–57. Chicago: Year Book Publishing Co., 1944.
7. Idem. J. Biol. Phot. Ass., 1945, 13, 139-145.

REPAIR IN THE NORMAL AND HYPERACID STOMACH

An Experimental Study

PHILIP B. PRICE, M.D., F.A.C.S., Salt Lake City, Utah

A RECENT experimental study of gastric digestion of living autogenous tissue provided unusual opportunities to observe the process of repair of wounds and incisions in the normal and hyperacid canine stomach. Those observations led to the present investigation.

A large number of healthy dogs were used. Discs of mucosa were excised from the gastric wall, and incisions and anastomoses of various sorts were made. The animals were sacrificed at selected intervals to note the progress of repair.

About half of the animals received daily intramuscular injections of histamine in beeswax beginning 24 hours after operation. The fasting gastric contents of this group of dogs averaged 91 units of free acid and 124 units of total acid. The other group, which received no histamine, had on the average 22 units of free acid and 61 units of total acid.

No. 60 cotton thread was used for the most part as suture material. Both cotton and fine catgut were tried in mucosa-to-mucosa suturing.

REPAIR OF WOUNDS IN THE NORMAL STOMACH

In the postoperative stomach of an otherwise normal dog, repair proceeds in a characteristic manner. Figure 1 illustrates schematically the healing process after a disc of mucosa and submucosa has been excised. First there is proliferation of fibroblasts and granulation tissue in the base of the defect (Fig. 1B) and turning down of the mucosal margins. This latter effect is probably due to digestion of underlying supportive submucosa. In a later stage of repair the base is heaped up with granulation tissue which may be covered with a thin slough of necrotic material. The wound is now smaller, thanks to fibrous and muscular contraction and the extreme laxity of the submucosa (Fig. 1C). From the under margins of the crests of mucosa new epithelium extends in sheets across the defect. At length the crests of mucosa meet like the heads of two rams (Fig. 1D) and the base becomes completely epithelialized. When that has occurred, digestion of tissue by gastric juice ceases and signs of inflammation subside.

Figure 2 is a photomicrograph of the margin of a healing wound after 4 days. The rounded crest of mucosa appears on the far left. There is a beginning of gland formation as well as active proliferation of epithelium which extends over the granulation tissue in the base of the wound. The muscularis mucosae is not seen in this view as it lags behind the advancing ram's head of mucosa.

If the original wound is large so that final healing is long delayed, the advancing margin of mucous membrane may be edematous (Fig. 3). In this edematous stroma one may see newly formed capillaries and lymph channels.

Figure 4 shows an originally large wound now almost completely healed. Beneath the mucosal union the muscularis mucosae layers approach each other. Healing at length will be so perfect that it is hard to find the scar

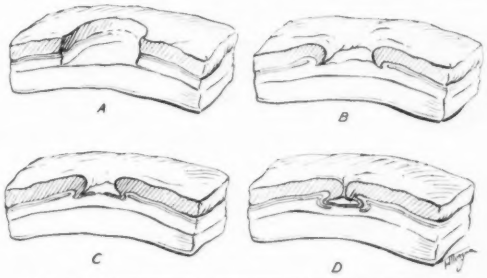

Fig. 1. Diagrammatic representation of stages in the repair of a wound in the mucosa of a normal stomach.

From the Department of Surgery, University of Utah, School of Medicine, Salt Lake City, Utah.

Presented in the Forum on Fundamental Surgical Problems before the Clinical Congress of the American College of Surgeons, Cleveland, Ohio, December 16-20, 1946.

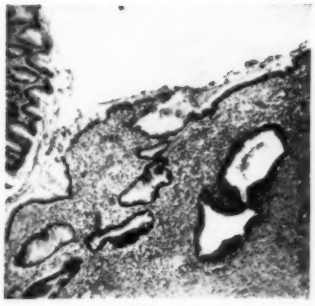

Fig. 2.

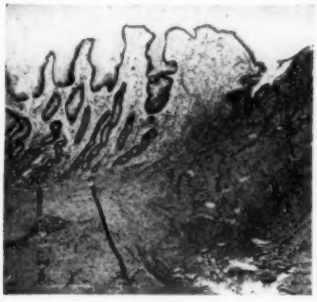

Fig. 3.

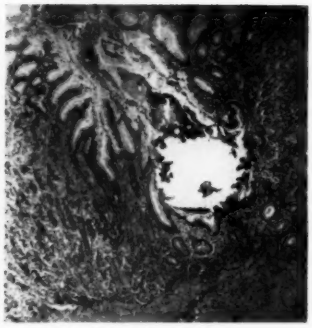

Fig. 4.

Fig. 5.

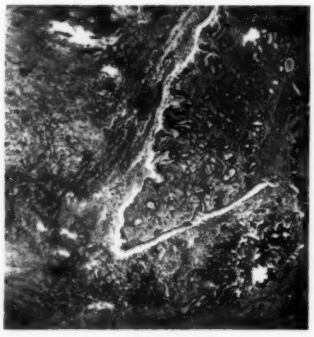

Fig. 6.

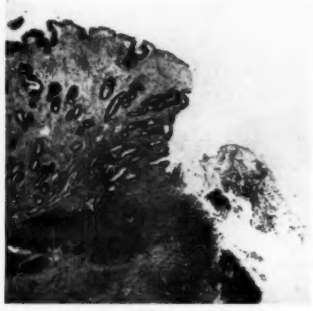

Fig. 7.

Fig. 8.

Fig. 2. The healing edge of an artificial mucosal defect, after 4 days; normal acidity.

Fig. 3. The healing edge of a very large mucosal defect, after 27 days; normal acidity.

Fig. 4. A large mucosal defect, virtually healed after 37 days; normal acidity. The remains of a cotton suture are seen in the center of the field.

Fig. 5. The edge of an artificial mucosal defect, after 2 days of hyperacidity.

Fig. 6. The edge of a mucosal wound, after 3 days of hyperacidity. The upper left-hand portion of the field is filled with cellular and necrotic débris being discharged into the lumen of the stomach.

Fig. 7. The edge of an acute spontaneous duodenal ulcer after 3 days of histamine injections.

Fig. 8. The edge of a gastric mucosal defect after 9 days of hyperacidity.

even on microscopic section. That is the normal process of healing.

REPAIR OF WOUNDS IN THE HYPERACID STOMACH

A very different picture is presented, however, when the gastric acidity is increased by daily intramuscular injection of histamine in beeswax. There is no evidence of epithelial proliferation on the third day (Fig. 5); instead, there are obvious erosion and disintegration of both margin and base of the wound.

One day later, there is an effort at proliferation deep in the projecting sulcus of the ram's

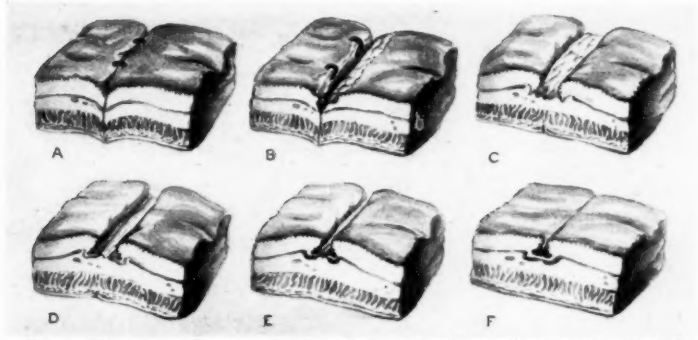

Fig. 9. Diagrammatic representation of stages in the repair of a sutured incision in a normal stomach.

head (Fig. 6), but the adjacent mucosa is hemorrhagic and the wound crater is filled with necrotic material, exudate, and blood.

Figure 7 shows the edge of a spontaneous duodenal ulcer found after only 3 days of histamine injections. Here also destruction has outrun repair. Even after 9 days there is little progress toward healing (Fig. 8); necrotic material and débris are about to be discharged into lumen of the stomach. The acid chyme in these cases not only hinders repair, it also erodes and digests the raw surfaces of the defect. Many animals in this particular experiment died of hemorrhage or perforation.

REPAIR OF INCISIONS AND ANASTOMOSES

These general principles apply also to repair of gastric incisions and lines of suture. Figure 9 illustrates diagrammatically the healing of a simple sutured incision in an otherwise normal gastric wall: A, the appearance immediately after suture; B, separation of the mucosal margins which soon occurs; c, characteristic rams' heads of mucosa, and connective tissue elements proliferating in the crevice; D, epithelium growing across in thin sheets from each side; E and F, further progress toward healing. Eventually the normal anatomical pattern will be restored.

Figure 10 shows the luminal part of an incision 48 hours after closure with 2 rows of sutures. The mucosal margins have separated and the intervening space is now filled with products of inflammation and erosion. Two days later (Fig. 11) the mucosal margins are in contact. The base is not yet covered with

Fig. 10.

Fig. 11.

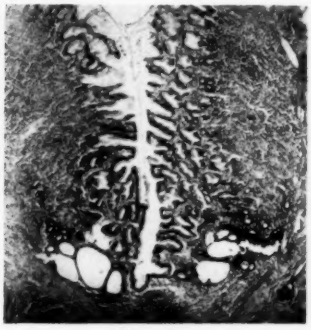

Fig. 12.

Fig. 10. Cross section of the luminal portion of a sutured gastric incision after 2 days; normal acidity.

Fig. 11. Cross section of a sutured gastric incision after 4 days; normal acidity.

Fig. 12. Cross section of a sutured gastric incision after 6 days; normal acidity.

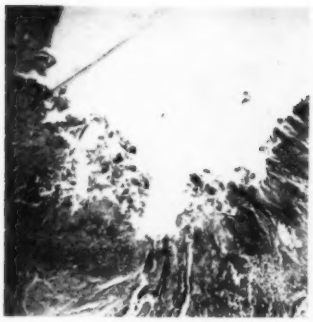

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

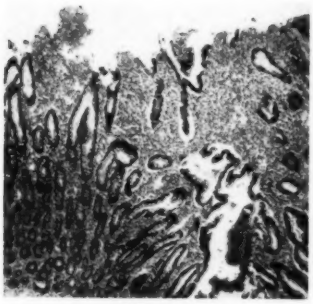

Fig. 18.

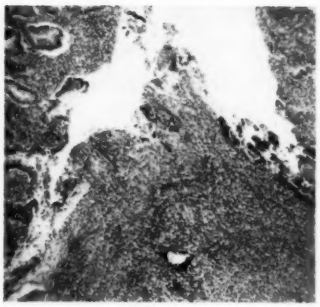

Fig. 19.

Fig. 13. Cross section of the luminal portion of a sutured gastric incision, after 2 days of hyperacidity.

Fig. 14. Cross section of the luminal portion of a sutured gastric incision, after 3 days of hyperacidity.

Fig. 15. The edge of a sutured gastric incision, after 5 days of hyperacidity. The mucosal margins are now widely separated.

Fig. 16. Cross section of a sutured gastric incision after 7 days of hyperacidity. ×10.

Fig. 17. Higher power view of one edge of same incision.

Fig. 18. A gastrojejunal anastomosis, virtually healed after 7 days.

Fig. 19. A gastrojejunal anastomosis, still unhealed after 12 days of hyperacidity.

epithelium, but it is protected from gastric juice and is clean and healthy. Six days after operation the incision is completely epithelialized (Fig. 12), and is, to all intents and purposes, healed. Grossly the incisions appear healed without inflammation.

In striking contrast is the healing of simple incisions in the strongly acid stomach. Fig-

ures 13 to 15 show the progressive deterioration which often occurs. There are ineffectual attempts at proliferation. Mucosal margins may become more widely separated day by day. Figure 16 shows a low power cross-section view of such an incision after 7 days. The line of suture is represented by a trough 7 millimeters in width; it is deep, grossly inflamed, and filled with products of deterioration and necrosis. Figure 17 is a photomicrograph of one edge of the trough.

This difference between rapid repair in the normal and imperfect repair or failure to repair in the hyperacid canine stomach is observed also in gastrojejunal anastomoses, though here the difference is somewhat less pronounced, probably because excess free acid is partly neutralized by alkaline intestinal contents. Figure 18 shows a gastrojejunal junction which in the presence of normal acidity is almost completely healed after 7 days. In contrast, a gastrojejunal suture in the presence of hyperacidity is shown in Figure 19. The anastomosis remains incompletely healed after 12 days; there is some extension of epithelium from both mucosal margins, but the intervening area, partly necrotic, is a poor surface upon which to lay down sheets of new epithelium.

COMMENT

Additional studies were made which show that defects and incisions in the process of healing under normal conditions tend to retrogress when the dog is given histamine in quantities sufficient to produce large amounts of strongly acid chyme. Conversely, unhealthy looking defects and incisions in the hyperacid stomach improve and proceed to heal rapidly when histamine is withdrawn.

It is recognized that hypoproteinemia interferes with healing in the gastrointestinal tract as elsewhere. In these acute experiments an attempt was made to eliminate that factor.

Obviously these effects produced in dogs under artificial experimental conditions should not be applied uncritically to clinical problems, but do provoke speculations and suggest practical points for further investigation.

They help, perhaps, to explain why peptic ulcers persist or enlarge in the presence of excessive amounts of acid, but tend to heal when by one means or another the acidity of the stomach is reduced to or below normal.

They suggest that healing of gastric incisions and anastomoses might take place more normally and rapidly if operations on the hyperacid stomach were followed in selected cases by a few days of antiacid medication. They also cast some doubt upon the value of the inner mucosa-to-mucosa suture used in gastric surgery—provided hemostasis is secured otherwise.

SUMMARY

Gross and microscopic studies were made of operative defects and sutured incisions in the gastric wall of normal dogs and dogs receiving daily injections in histamine-in-beeswax.

In approximately 100 normal dogs no spontaneous ulcers were observed. Artificial defects in the gastric wall and lines of incision all showed relatively rapid healing characterized by minimal autodigestion, relatively mild inflammatory reaction, protective and reparative fibrosis, vigorous proliferation of gastric epithelium, and early approximation of the mucosal margins.

In dogs with hyperacidity, on the contrary, spontaneous ulcers, artificial defects, and sutured incisions all showed inflammation, necrosis, and autodigestion. Fibrosis and granulation tissue were present, but gave the appearance of being unsuccessful barriers to a progressively destructive process. Epithelial regeneration was generally slight or absent, and in many instances there was progressive undermining and destruction of marginal gastric mucosa. The severity of the erosive process was roughly proportional to the degree of acidity of samples of fasting gastric contents

These two conditions, of normal repair and of failure to repair in the presence of hyperacidity, could be made to change from one to the other by giving or withdrawing histamine.

With due caution in applying experimental results to clinical problems, it is suggested that these observations may help to explain the healing or persistence of peptic ulcers.

The question is raised whether operations upon the hyperacid stomach should not be followed by a few days of antiacid therapy.

The value of the conventional mucosa-to-mucosa suture in gastric surgery is doubtful.

PAINFUL HEELS IN CHILDREN

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PAINFUL heels in children are believed by many to be due commonly to an osteochondrosis of the epiphysis of the os calcis. There have been few reports on the histology of the condition. Hass in 1931 found gross disorganization of an epiphysis but Bergmann in 1926 and Frejka in 1927 both noted an absence of any abnormality. It has been suggested that the diagnosis depends on radiological signs; but there is no uniformity of opinion as to what may be regarded as the typical x-ray appearances (Table I).

The epiphysis, the epiphyseal line, and the neighboring metaphysis have all been described as showing abnormal roentgenological features. Since it is on the recognition of these latter that the condition is classified as an osteochondrosis or epiphysitis, a large series of roentgenograms were first studied in order to establish the variations in this region in normal children.

THE EPIPHYSIS

Ossification begins in the epiphysis between the 6th and 8th years at multiple centers just below the middle of the posterior aspect of the os calcis. Extension takes place inferiorly, superiorly, and posteriorly, and by the 9th year the epiphysis appears roentgenologically as a cap covering the lower two-thirds of the posterior aspect of the os calcis. During the 10th to the 12th years the remainder of the epiphyseal cartilage ossifies; the upper one-third remains as a very thin plate of bone and like the most inferior portion of the epiphysis frequently begins from a separate center. By the 14th year, therefore, the epiphysis is roughly C-shaped and extends from the posterior and superior corner of the metaphysis to the posterior part of the plantar surface.

The epiphysis is usually denser than the body of the os calcis; segmentation of the ossifying area into two or more segments is not uncommon. The edge of the epiphyseal ossification may be well defined or may be irregular and fluffy. The bone trabeculae run parallel to the surface and are usually, but not always well marked.

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THE EPIPHYSEAL LINE

During the 9th year the lower lateral edges of the epiphyseal ossification curve forward; this expansion considerably alters the roentgenological appearances because it obscures in this part the clear radiotranslucent line between the epiphysis and the metaphysis. Both the medial and lateral edges of the ossifying plaque can be seen, frequently on either side of the posterior edge of the metaphysis of the os calcis. The epiphyseal line is finally entirely obliterated at approximately the 15th to 16th years.

TABLE I.—RADIOLOGICAL SIGNS OF "EPIPHYSITIS" OF THE OS CALCIS

		Reference
1	Enlargement of the epiphysis	14, 15, 17
2	Flattening of the epiphysis	1, 11, 16
3	Subchondral bone destruction or absorption of the epiphysis	1, 7
4	Increased density of the shadow of the epiphysis	4, 12, 13, 18, 19
5	Irregularity of the epiphysis	6, 14, 15, 16, 18
6	Fluffy appearance of the epiphysis	7, 12, 19
7	Segmentation of the epiphysis	1, 3, 4, 5, 7, 11, 13, 15 16, 18, 19
8	Fracture of the epiphysis	9
9	Calcareous deposits in the lower part of the epiphysis	6
10	Displacement of the epiphysis up and back	6
11	Abnormal gap between the epiphysis and the body of os calcis	6, 9
12	Considerable cloudiness along the epiphyseal line between the affected epiphysis and os calcis	14, 15, 16, 17
13	Unusual irregularity of the adjacent posterior surface of the body of the os calcis	7, 12, 13, 16
14	Areas of rarefaction in the metaphysis	4

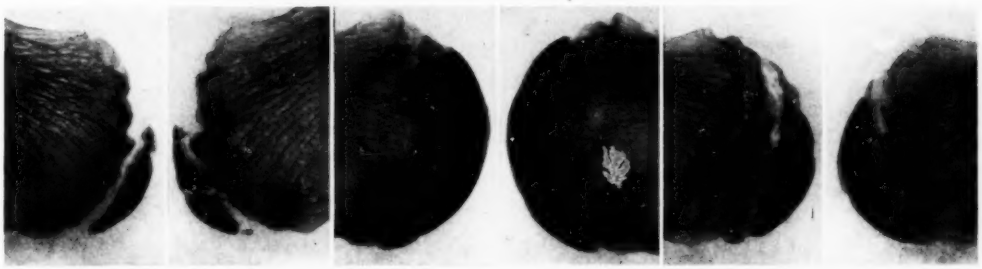

Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6

Fig. 1. D. G., male, 10 years old, right heel.
Fig. 2. Same patient as in Figure 1, left heel.
Fig. 3. M. C., male, 14 years old, right heel.
Fig. 4. Same patient as in Figure 3, left heel.
Fig. 5. R. E., male, 12 years old, right heel.
Fig. 6. Same patient as in Figure 5, left heel.

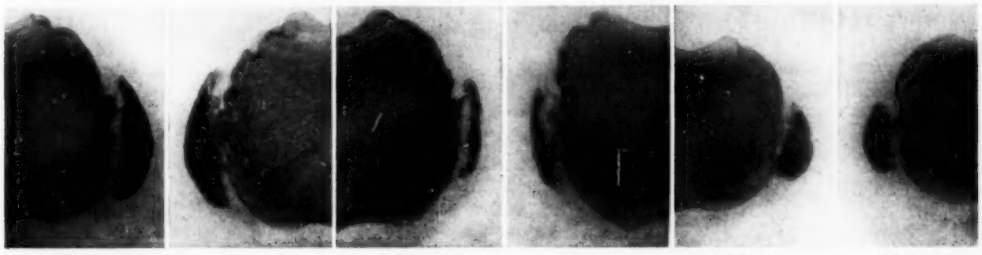

Fig. 7 Fig. 8 Fig. 9 Fig. 10 Fig. 11 Fig. 12

Fig. 7. D. S., male, 11 years old, right heel.
Fig. 8. Same patient as in Figure 7, left heel.
Fig. 9. J. P., male, 10 years old, right heel.
Fig. 10. Same patient as in Figure 9, left heel.
Fig. 11. M. W., female, 7 years old, right heel.
Fig. 12. Same patient as in Figure 11, left heel.

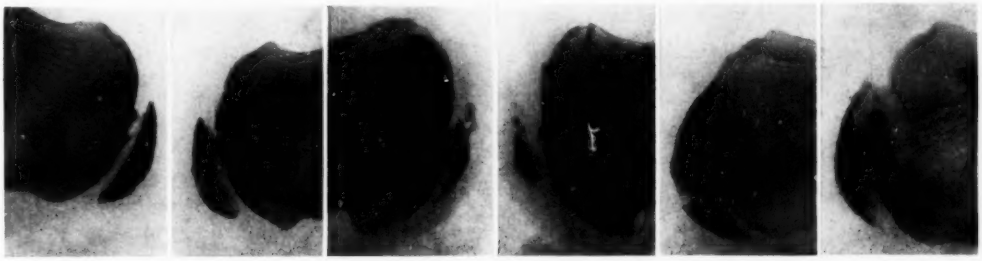

Fig. 13 Fig. 14 Fig. 15 Fig. 16 Fig. 17 Fig. 18

Fig. 13. P. O., female, 9 years old, right heel.
Fig. 14. Same patient as in Figure 13, left heel.
Fig. 15. P. S., male, 11 years old, right heel.
Fig. 16. Same patient as in Figure 15, left heel.
Fig. 17. R. M., male, 11 years old, left heel.
Fig. 18. C. P., male, 10 years old, left heel.

THE METAPHYSIS

Trabeculae radiating posteriorly and inferiorly from the posterior subastragaloid joint are grouped into a slightly dense band passing to the cortex of the posterior surface and another passing to the posterior and inferior angle. Other trabeculae sweeping posterosuperiorly from near the anterior end of the plantar surface of the os calcis intersect these former. The posterior surface of the os calcis becomes roughened and the previous sharp line on the roentgenogram is replaced by irregular ridges. These irregularities of the posterior end of the metaphysis, together with the overlapping by the edges of the epiphyseal ossification and the arrangement of the bony

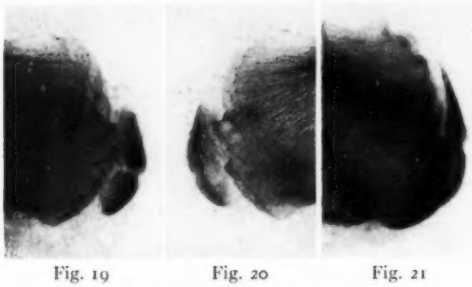

Fig. 19 Fig. 20 Fig. 21

Fig. 19. N. C., male, 11 years old, right heel.
Fig. 20. Same patient as in Figure 19, left heel.
Fig. 21. N. S., female, 10 years old, right heel.

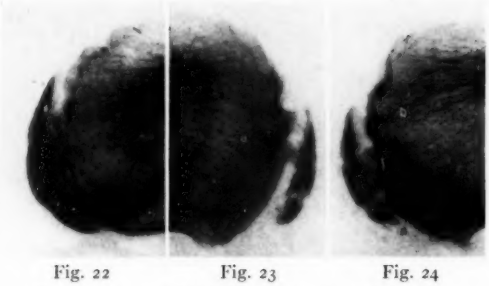

Fig. 22 Fig. 23 Fig. 24

Fig. 22. Same patient as in Figure 21, left heel.
Fig. 23. R. H., male, 10 years old, right heel.
Fig. 24. Same patient, left heel (symptomless).

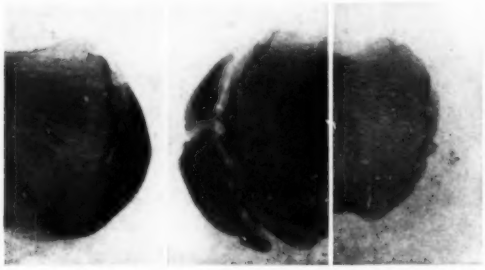

Fig. 25 Fig. 26 Fig. 27

Fig. 25. P. H., female, 11 years old, right heel.
Fig. 26. A. W., female, 10 years old, left heel.
Fig. 27. H. F., female, 6 years old, right heel.

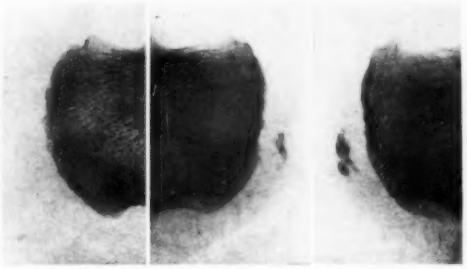

Fig. 28 Fig. 29 Fig. 30

Fig. 28. Same patient, left heel (symptomless).
Fig. 29. A. B., male, 8 years old, right heel.
Fig. 30. Same patient as in Figure 29, left heel.

trabeculae result in areas of apparent rarefaction and density of the metaphysis.

ROENTGENOLOGICAL APPEARANCES OF PAINFUL ADOLESCENT HEELS (Figs. 1 to 42)

Since 1939, 23 children (17 boys and 6 girls) have sought treatment for painful heels (16 with bilateral symptoms); their ages varied from 6 to 14 years. Pain was intermittent but persistent, usually precipitated by exercise and referred to the sides, the back, or the inferior aspect of the heel. Apart from slight tenderness in 12 cases, there was a complete absence of physical signs. The roentgenograms of the heels of these patients presented a wide variety of appearances. The epiphysis sometimes seemed enlarged or flattened or irregular or segmented or sometimes presented a mottled or fluffy appearance; the epiphyseal line was often cloudy and united the epiphysis to the irregular posterior surface of the body of the os calcis. When studied in conjunction with the normal series it became clear that none of these x-ray films presented pathological features.

DISCUSSION

In 1908, Haglund reported 2 "rare but important surgical injuries brought on by violent exercise"; the first involved the tibial tuberosity and the second the epiphysis of the os calcis which he believed to be fractured or separated from the metaphysis. Sever, in 1912, reported 5 cases of "apophysitis" of the os calcis and compared the condition with Osgood-Schlatter's disease. A year later, Edmond described irregular epiphyses in 2 boys each aged 13 years. Since then isolated cases and small series have been reported and most authors have followed Sever in classifying the condition as an osteochondrosis, which implies an abnormality of the developing epiphysis.

Fig. 31 Fig. 32 Fig. 33 Fig. 34 Fig. 35 Fig. 36

Fig. 31. R. B., male, 9 years old, right heel.
Fig. 32. Same patient, left heel (symptomless).
Fig. 33. E. B., male, 11 years old, right heel.
Fig. 34. Same patient as in Figure 33, left heel.
Fig. 35. D. S., male, 10 years old, right heel.
Fig. 36. Same patient as in Figure 35, left heel.

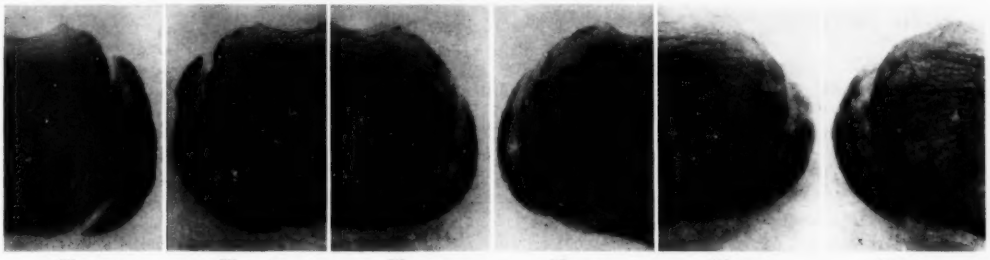

Fig. 37 Fig. 38 Fig. 39 Fig. 40 Fig. 41 Fig. 42

Fig. 37. E. S., male, 13 years old, right heel.
Fig. 38. Same patient as in Figure 37, left heel.
Fig. 39. D. B., male, 11 years old, right heel.
Fig. 40. Same patient as in Figure 39, left heel.
Fig. 41. D. O., male, 11 years old, right heel.
Fig. 42. Same patient as in Figure 41, left heel.

In favor of this view is the absence of any other apparent cause for the painful heel and the undoubted fact that some films of normal feet display an epiphysis with regular edges. It has been claimed that the age period is characteristic; but a painful heel is not uncommon at any age and frequently the underlying etiology is obscure.

There are certain facts, however, that do not support this classification. There is a lack of any histological proof of the disease. After a survey of our films and of those published by other authors it is impossible to agree that these differ in any way from a normal series of films. A follow-up examination revealed no residual anatomical abnormality in the heel, clinically or roentgenologically, despite the fact that pain sometimes persisted after fusion of the epiphysis and diaphysis.

The epiphysis may be involved in juxta-epiphyseal affections of the os calcis (Figs. 43, 44, 45). But in such cases the primary metaphyseal lesion can be seen and roentgenologically the epiphyseal damage is restricted to a localized rarefaction and partial avascular necrosis. These appearances are not comparable with those found in painful adolescent heels.

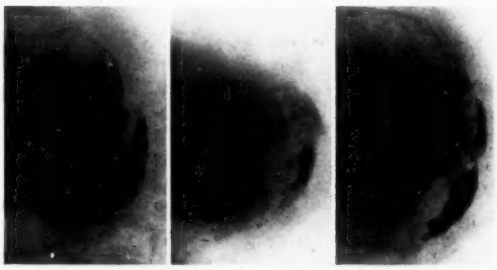

Fig. 43 Fig. 44 Fig. 45

Figs. 43 and 44. R. G., male, 9 years old, painful heel of 6 weeks' duration followed by swelling and later sinus formation on medial side. Tuberculosis of os calcis.
Fig. 45. J. D., male, 12 years old, painful swollen heel for 6 weeks followed by sinus formation. Tuberculosis of os calcis.

This investigation leads to the conclusion that there is no proof that osteochondrosis or epiphysitis (or apophysitis) is the underlying cause of these adolescent painful heels.

SUMMARY

1. A description has been given of the normal variations in the appearances of the ossifying epiphysis of the os calcis.

2. The clinical and radiological features of 39 painful heels in children between the ages of 6 and 14 years old are described.

3. It is concluded that there is insufficient proof that osteochondrosis is ever the underlying cause of adolescent painful heels.

REFERENCES

1. ALLISON, N. J. Bone Surg., 1924, 22: 91–94.
2. BERGMANN, E. Arch. klin. Chir., 1926, 141: 463.
3. BRAILSFORD, J. F. The Radiology of Bones and Joints. London: J. & A. Churchill Ltd., 1935.
4. BURNS, B. H., and ELLIS, V. H. Recent Advances in Orthopaedic Surgery. London: J. & A. Churchill Ltd., 1937.
5. CHRISTIE, A. C. J. Am. M. Ass., 1926, 87: 291–295.
6. EDMOND, W. Brit. M. J., 1913, 1: 443.
7. FAIRBANK, H. A. T. Proc. R. Soc. M., Lond., 1924, 18: 1–11.
8. FREJKA, B. Cas. lék. cesk., 1927, 66: 1087.
9. HAGLUND, P. Lancet, Lond., 1908, 2: 12.
10. HASS, J. Rev. orthop., Par., 1931, 18: 383.
11. JONES, SIR ROBERT, and LOVETT, R. W. Orthopaedic Surgery. London: Oxford Medical Publications 1933.
12. KING, E. S. J. Localised Rarefying Conditions of Bone. London: Edward Arnold & Co., 1935.
13. LAKE, N. C. The Foot. London: Baillière, Tindall & Cox, 1938.
14. LEWIN, P. Surg. Gyn. Obst., 1928, 41: 579–582.
15. MERCER, W. Orthopaedic Surgery. London: Edward Arnold & Co., 1943.
16. MEYERDING, H. W., and STUCK, W. G. J. Am. M. Ass., 1934, 102: 1658.
17. SEVER, J. W. N. York M. J., 1912, 95: 1025.
18. SHANDS, A. R. Handbook of Orthopaedic Surgery. London: Henry Kimptom, 1940.
19. SIMON, H. E., and WILLIAMSON, B. J. Bone Surg., 1939, 21: 1015–1019.

ACUTE PANCREATITIS

A Statistical Review of 307 Established Cases of Acute Pancreatitis

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THIS study was undertaken with two objectives in mind: first, to improve our diagnostic accuracy by a proper classification, correlation, and understanding of the clinical picture; and, second, to determine the proper treatment of acute pancreatitis. In addition, this report is justified as a statistical review as it represents a series of cases approximately four times larger than any group previously reported.

We shall neither discuss the etiology of acute pancreatitis nor review the literature.

MATERIAL

An established diagnosis of acute pancreatitis was made in 307 patients admitted to the Los Angeles County General Hospital during the period between January 1933 and January 1946. One hundred fifty-nine cases of the 307 were diagnosed by definite elevation of the blood amylase or urinary diastase; 103 cases were diagnosed at surgery; and 45 were either diagnosed or the diagnosis substantiated at the autopsy table.

CLINICAL PICTURE

Acute pancreatitis may affect all age groups. The youngest in this series was an 11 year old girl; the oldest, an 86 year old man. The average male was 41; the average female was 49. The majority of the patients were in the third decade of life.

Acute pancreatitis was more common in the women than in the men. There were 138 males and 169 females.

It has long been our clinical impression that this disease is more prevalent during warm weather. There was a higher incidence of acute pancreatitis during the hot summer months.

The initial pain began immediately after the ingestion of a heavy meal in 76 instances (25%), a positive point in the history which can be of real diagnostic value. Repeated experiments have shown that pancreatic necrosis is more readily produced soon after the ingestion of a heavy meal—presumably, when the pancreas is active producing digestive substances.

An unusually large percentage of these patients had previous similar—but less severe—attacks. These episodes were generally mild and of short duration subsiding within 24 to 48 hours. There is universal agreement that these episodes represent a mild form of the disease and are commonly referred to as edematous pancreatitis or acute interstitial pancreatitis. The patient, however, may refer to them as indigestion, gastritis, or dyspepsia. It is not uncommon for a fatal attack to be preceded by several mild attacks. A past history typical of acute pancreatitis was elicited in 43 per cent of our patients. An additional 18 per cent had had some previous gastrointestinal difficulty suggesting the mild form of the disease. Therefore, 61 per cent of the 307 patients probably had had previous attacks.

Only recently has the rôle of alcoholism in the pathogenesis of acute pancreatitis received any attention. Fifty-five patients (18%) were admitted intoxicated or were recuperating from a recent alcoholic bout. We are certain that had more of the alcoholics been studied for acute pancreatitis, a greater number would have been included in this report.

SYMPTOMS

TABLE I.—SYMPTOMS

	Number of cases	Per cent
Pain	290	94.5
Nausea	291	94.6
Vomiting	258	84.0

The 3 predominating symptoms in the acute phase of the disease are: (1) pain, (2) nausea, and (3) vomiting. Of the 307 patients, 290 had abdominal pain. Sixteen were admitted

From the Department of Surgery of the University of Southern California School of Medicine and the Los Angeles County General Hospital. Presented to the sectional meeting of the American College of Surgeons at Los Angeles, California. April 18, 1946.

in coma with no history. One patient with epidemic parotitis had no abdominal pain. This patient developed persistent nausea and vomiting during the acute phase of mumps. Both the blood amylase and urinary diastase were significantly elevated. A clinical diagnosis was made of mild acute pancreatitis secondary to the parotitis.

The pain was epigastric in location in 114 cases; epigastric radiating to the back in 122 cases; epigastric in origin, becoming generalized, in 38 cases. However, of this group with upper abdominal pain, there were 39 cases in which the pain originated in the right upper quadrant and radiated through to the back simulating acute cholecystitis. On examination, unilateral or bilateral flank tenderness was found. Flank pain and tenderness is of definite diagnostic significance in acute pancreatitis.

Seventeen patients presented an unusual pattern for acute pancreatitis in that the pain began suprapubically and radiated to one or both flanks. This distribution of pain in any acute condition within the abdomen is not particularly common. When this syndrome presents itself, the blood amylase and urinary diastase should always be determined.

Eighty-four per cent of the 307 patients had nausea and vomiting. Reflex vomiting appears early and is generally persistent. Later in the course of the disease, the vomiting is variable dependent upon the amount of ileus present or the degree of duodenal obstruction from the enlarging pancreas. The absence of nausea and vomiting was not sufficiently characteristic in any syndrome to have statistical significance.

From a clinical standpoint, the disease usually falls into one of five groups. In *Group 1* is seen the standard textbook description of acute pancreatitis—an elderly, obese, florid individual who has eaten a large meal preceded by several highballs. A few hours later, he is seized with excruciating upper abdominal pain followed immediately by nausea and profuse vomiting. Generally, he is in profound shock with cyanotic mottled skin and diffuse abdominal rigidity and tenderness. Peristalsis is infrequent or absent. Later, he may have ecchymosis of the flanks or the umbilicus. Death ensues within 24 to 36 hours with a terminal hyperpyrexia (105 to 106 degrees F.). The patient who simulates acute coronary occlusion is included in this group. Four patients had substernal pain with radiation to the epigastrium. In 2 other cases, the pain was localized in the precordium. These 6 patients were admitted with a diagnosis of acute coronary occlusion. In 3 of these, fat necrosis was observed in the left pleura and the pericardium at the post mortem.

Group 2 simulates acute cholecystitis. The onset is usually sudden with moderately severe epigastric or right upper quadrant pain. The pain often radiates through to the back and is followed at once by nausea and persistent vomiting. In the past, the patient has experienced similar seizures, but jaundice is not often reported. Thirty-nine patients in this series gave such a history. On admission, in 33 of the 39 an erroneous diagnosis of acute cholecystitis was made.

Group 3 imitates mechanical small intestinal obstruction. These patients are seemingly so characteristic that a diagnosis of mechanical small intestinal obstruction is made in the admitting room. However, there is no apparent etiology—such as hernia or abdominal scar—for the obstruction. Any patient who appears to have an intestinal obstruction without obvious etiology should have a blood and urinary diastatic activity determined before surgery is contemplated. In 26 patients in this series first a diagnosis of intestinal obstruction was made—later, of acute pancreatitis.

Group 4 resembles acute alcoholism with acute gastritis. Included in this category are those patients that are thought to have perforated a peptic ulcer. Patients in this group often are admitted either intoxicated or they give a history of having been on a recent, prolonged, alcoholic spree. Subsequently, they develop abdominal pain, nausea, and vomiting. However, these symptoms may be minimal. The slight degree of abdominal rigidity often leads to the mistaken diagnosis of a slow-leaking, peptic ulcer. The known high frequency of acute pancreatitis during or following acute alcoholism compels us to determine the diastatic activity of the blood and urine as a routine measure.

Group 5 comprises those patients who, on admission, have a mass either in the epigastrium or the left upper quadrant. Approximately 3 to 4 weeks prior to admission, they had acute pancreatitis. A pancreatic abscess, a pseudocyst, or inflammatory exudate remained as a tender mass. Their initial symptoms may fall into any of the four groups described.

ASSOCIATED SYMPTOMS

TABLE II.—ASSOCIATED SYMPTOMS

	Number of cases	Per cent
Diarrhea	22	7.1
Bloody diarrhea	14	4.5
Hematemesis	10	3.1
Hypertension	60	19.5

Gastrointestinal hemorrhage. An extremely interesting symptom which may confuse the clinical diagnosis is gastrointestinal hemorrhage. Twenty-four of our patients had massive gastrointestinal hemorrhage—14 times as a bloody diarrhea and 10 times as a bloody vomitus. At the postmortem examination, numerous areas of hemorrhagic ulceration were observed in the mucosa of the stomach, small intestine, and colon. After a cursory examination of the voluminous literature on pancreatitis, we have not found any reference to these hemorrhagic areas of ulceration. Further study is now in progress to establish the cause and exact nature of these hemorrhagic areas and will be reported at a later date.

It has been demonstrated that the tryptic action of the pancreatic enzymes can produce vascular necrosis and hemorrhage in all tissues of the body. This may be the cause of the ulceration (Fig. 1).

Diarrhea. Diarrhea may be a misleading symptom in the differential diagnosis of acute pancreatitis. It was present in 22 of our 307 cases. The diarrhea is caused by the initial increase in peristaltic movements produced by the irritation of the autonomic nerve supply to the intestine. Probably, the absence of pancreatic enzymes in the intestine is a contributing factor. Constipation, however, is more common than diarrhea.

Clinical hypertension. Twenty per cent had clinical hypertension. It is significant that the average age of this group of patients (41 years for males—49 years for females) is not in the decade when hypertension would be expected. This observation varies from the widespread belief that profound shock is generally present. As can be seen from Table III, only 11.7 per cent were in "shock." Two hundred thirty-seven cases (78%) had no clinical evidence of shock.

Fig. 1. Segment of ileum showing hemorrhagic ulceration of the mucosa.

TABLE III.—DEGREE OF SHOCK

	Number of cases	Per cent
None	237	78.0
Moderate	19	6.2
Severe	36	11.7

The degree of shock principally depends on the pathology present. None will deny the presence of irreversible hypotension in the patient with widespread destruction of the pancreas. In the early stages, this reduction of blood pressure represents a neurovascular reaction excited by pain and tissue destruction. Later, it merges gradually into secondary shock without an interval of partial recovery and precedes death in a state of severe peripheral vascular collapse. The state of peripheral vascular collapse is the probable explanation of the "peculiar cyanosis" exhibited by the patient. This is not to be confused with the brownish discoloration of the flanks (Grey-Turner sign) or the slate-blue color of the umbilicus (Cullen's sign). These are produced by an entirely different mechanism.

ASSOCIATED PATHOLOGY

Listed in Table IV are the various pathological lesions which were associated with these cases of acute pancreatitis.

TABLE IV.—PATHOLOGY

	Number of cases	Per cent
Biliary tract disease	125	40.7
Alcoholism	55	18.0
Trauma	3	
Postoperative	3	
Perforated ulcer	2	
Mumps	1	
Postpartum	1	
No associated pathology	117	38.0

Each condition has been listed as probable etiological factors.

DIAGNOSIS

Table V lists the admitting diagnoses made in the series.

TABLE V.—ADMITTING DIAGNOSIS

	Number of cases	Per cent
Pancreatitis	150	48.8
Cholecystitis	33	10.8
Perforated ulcer	50	16.3
Intestinal obstruction	26	8.5
Appendicitis	12	3.9
Gastrointestinal hemorrhage	8	2.6
Alcoholism	7	2.3
Coronary occlusion	6	1.9
Miscellaneous	15	4.9

Acute pancreatitis may be suggested by the symptoms and findings, but we must depend on the laboratory to establish the clinical diagnosis. The various laboratory aids in the diagnosis are: (1) elevated blood amylase; (2) elevated urinary diastase; (3) depressed blood calcium; (4) roentgenogram of the abdomen; (5) changes in the electrocardiogram; (6) elevated blood sugar; (7) sugar in the urine.

DIASTATIC ACTIVITY

A definite elevation in the blood amylase usually occurs within the first 24 hours. Frequently, a patient with acute pancreatitis has a normal serum amylase during the first 8 to 12 hours. This fact must be considered in correlating the laboratory findings with the stage of the disease. The blood amylase remains elevated 24 to 72 hours depending upon the severity of the disease. It usually returns to normal before the clinical subsidence of the disease. Here again, the time element must be considered in establishing the presence of acute pancreatitis. The urinary diastase usually becomes elevated 12 to 24 hours later than the elevation of the blood amylase. It remains elevated 24 hours or more longer than the elevated amylase. This, however, is not constant. The variability in the time of elevation of both the amylase and diastase is impressive. It is recommended that both the blood amylase and urinary diastase be done simultaneously in any suspected case of acute pancreatitis regardless of the elapse of time since the onset of the disease.

It must be remembered that the blood and urinary diastatic levels may be normal in cases that have widespread destruction of the pancreas. Apparently, the gland is completely destroyed and the enzymes in the serum drop to normal or subnormal levels.

We use a rapid method of determination which was devised by Doctor Albert Chaney of the Los Angeles County General Hospital biochemical laboratory. It is a modification of the Somogyi method. This method has proved very satisfactory.

BLOOD CALCIUM

The blood calcium may become depressed due to the utilization of the ionizable calcium. Pancreatic lipase acts upon the fats splitting them into glycerol and free fatty acids. Calcium soaps are formed by a combination of the free fatty acids and the ionizable calcium. These calcium soaps have been observed many times at surgery and necropsy—also in roentgenograms of the abdomen. This depression of the calcium may be severe enough to produce clinical tetany. This has been reported by Doctors Edmondson and Berne and Doctors Edmondson and Fields.

ROENTGENOGRAM

In the later stage of the disease, the x-ray picture of the abdomen frequently shows a segmental type of ileus which may involve the stomach, small intestine, or colon. The transverse colon exhibits this selective segmental ileus more often than the rest of the bowel. One hundred twenty-five of the 307 patients had emergency scout films of the abdomen—82 cases (68%) revealed a segmental type of ileus. This segmental distribution of gas is not pathognomonic of acute pancreatitis roentgenographically, but it certainly suggests the diagnosis.

ELECTROCARDIOGRAM

A small group of patients with acute pancreatitis will exhibit changes in the electrocardiogram. Although these changes are nonspecific, they are suggestive enough for the diagnosis to be considered. They are thought to be caused by a low calcium level. Positive correlation has been made between the blood calcium level and electrocardiographic changes. Ralph E. Homann has published a critical study of the electrocardiographic changes.

GLYCOSURIA AND HYPERGLYCEMIA

Some patients with acute pancreatitis spill sugar into their urine. They also have an increase in the blood sugar level. During the early years of this study, urinalyses were not done in all patients. Therefore, it would be a statistical fallacy to include part of the group giving the incidence of sugar. The elevated blood sugar level usually was high in the patients who had glycosuria. In 1 case, it was 1500 milligrams per 100 cubic centimeters of blood. In this group, there was no preceding history suggestive of diabetes. One must assume that the glycosuria is secondary to the acute pancreatitis. In the literature, there are several articles pointing out that diabetes may result from acute pancreatitis. This we have seen many times.

TREATMENT

The treatment of choice in uncomplicated acute pancreatitis is not surgical. Conservative treatment is recommended because of the results obtained. The objective of the treatment is to place the pancreas at rest. Pancreatic activity may be decreased by the following measures: (1) continuous gastrointestinal suction, (2) adequate parenteral fluids, (3) regular use of morphine sulfate, and (4) regular doses of atropine sulfate.

Continuous gastrointestinal suction is of extreme importance. By preventing the acid gastric secretions from entering the duodenum, the hormonal stimulation of the pancreas is reduced to a minimum. In addition, acute gastric dilatation is prevented and the ileus which develops is successfully treated.

The fluid and caloric requirements are met by administering 3000 to 4000 cubic centimeters of 5 per cent glucose solutions daily. No insulin is given unless it is necessary in the treatment of associated diabetes.

Regular injections of morphine sulfate (gr. 1/6 to gr. 1/4) are used to relieve the severe pain of the pancreatic necrosis and to place the gastrointestinal tract at rest. Remarkable relief from pain is obtained by a procaine block of the paravertebral sympathetic ganglia (T4-9). It is also known that the sympathetic supply excites external pancreatic secretion. A splanchnic block with single injection probably would be preferable.

Atropine sulfate is given in large doses (gr. 1/75 to gr. 1/100) every 3 to 4 hours. This effort is designed primarily not to relax the sphincter of Oddi but to suppress the vagus mechanism. Stimulation of the vagus produces a concentrated pancreatic juice rich in enzymes.

Reverse Trendelenburg position favors respiration without the hazard of obstructing the return venous flow.

One additional measure that may favorably alter the course of acute pancreatitis is the use of x-ray therapy. This is given during the acute phase of the disease. An analysis of our experience with this therapy is to be reported at a later date by Doctor Leo Levi of the Department of Radiology, Los Angeles County General Hospital.

Patients with acute pancreatitis on the treatment outlined may show rapid clinical improvement. Other than a slight elevation in temperature, the patients have no symptoms or findings of acute pancreatitis. Diastatic activity is within the normal range. If the gastrointestinal suction is discontinued and oral feeding started, an exacerbation of the disease results. It is our policy to continue the intensive conservative treatment until the temperature has been normal for a minimum of 48 hours. The febrile response is an important guide in determining when treatment can safely be discontinued.

A review of the literature concerning the treatment of acute pancreatitis indicates a predominance of opinion in favor of immediate surgical interference. It has long been our clinical impression that the mortality in those patients with acute pancreatitis who are operated

upon—irrespective of the procedure performed—is definitely greater than the mortality in those that are not operated upon. The following report on the results substantiate our impression.

Table VI indicates the total number of cases as 307 with 102 deaths—a mortality of 33.3 per cent. Of the 307 patients, 103 were operated upon with 46 deaths—a mortality of 44.7 per cent. In the group that were not operated upon, there were 204 patients with 56 deaths—a mortality of 27.5 per cent.

MORTALITY

TABLE VI.—MORTALITY

	Number of cases	Deaths	Per cent
Operated upon	103	46	44.7
Not operated upon	204	56	27.5
Moribund	16	16	100.0
Not operated upon less moribund	188	40	21.3
Total	307	102	33.3

However, of these 56 deaths in patients who were not operated upon, 16 patients were admitted *in extremis*. Therefore, they should not be classified in either category insofar as the effects of any specific therapy is concerned. If this moribund group of 16 cases is deducted from the 204 patients treated without surgery, 188 cases remain with 40 deaths—a 21.3 per cent mortality.

In the group operated upon during the acute phase of the disease, Table VII indicates the various types of operations performed, the number of cases, and the deaths. These data statistically have no significance except to point out that irrespective of the procedure, the end-results are poor.

TABLE VII.—OPERATIONS

	Number of cases	Deaths	Per cent
Exploration	53	24	45.2
Cholecystostomy	21	9	42.8
Drainage of pancreas	10	5	50.0
Cholecystectomy	8	3	37.5
Cholecystostomy and pancreatic drainage	5	1	20.0
Cyst drained	1	1	100.0
Cholecystectomy and common duct drainage	5	3	60.0

A study that we have started which is far from complete but which we wish to mention at this time is an operative procedure designed to prevent recurrences. The surgery referred to is section of the vagus nerves. Division of the vagus nerves will interrupt the two important stimuli to the pancreas. The hormonal stimuli will be reduced to a minimum by decreasing the acid secretion of the stomach. The direct stimulation to the pancreas will be diminished greatly. To our knowledge, only 2 patients have had vagus sections for this disease. One was done on our service at the Los Angeles County General Hospital, and the other, in a private hospital by another member of our staff (Doctor A. C. Pattison). A detailed report of these cases will be published later.

SUMMARY AND CONCLUSIONS

1. We have presented a critical review of 307 established cases of acute pancreatitis in patients admitted to the Los Angeles County General Hospital during the past 13 years.

2. Five clinical syndromes of acute pancreatitis are described. Attention is directed to several important signs and symptoms. These are: (a) massive gastrointestinal hemorrhage, (b) diarrhea, (c) segmental ileus seen on the emergency scout film, (d) alcoholism, (e) the electrocardiographic changes, (f) absence of shock, and (g) presence of hypertension.

3. Blood amylase and urinary diastase determinations if correlated with the stage of the disease are the most important aids in the diagnosis. It is recommended that both the blood amylase and urinary diastase be done simultaneously in any suspected case of acute pancreatitis.

4. The febrile response is the important guide in determining when treatment can safely be discontinued. Premature discontinuation of active therapy will result in reactivation of the disease.

5. There was an over-all mortality of 33.3 per cent. The patients that were operated upon as emergencies had a mortality of 44.7 per cent. In the group that was not operated upon, the mortality was 21.3 per cent indicating that conservative therapy is superior to any operative procedure during the active phase of acute pancreatitis. This we believe is equally true in either the acute edematous pancreatitis or the hemorrhagic variety.

REFERENCES

1. Adams, A. W. Brit. M. J., 1939, 2: 854.
2. Archibald, E. Surg. Gyn. Obst., 1919, 28: 529.
3. Idem. Proc. Inst. M., 1940, 13: 134.
4. Baxter, H., Baxter, S. G., and McIntosh, J. F. Am. J. Digest. Dis., 1938, 5: 423.
5. Bisgard, J. D., and Baker, C. P. Ann. Surg., 1940, 112: 1006.
6. Casber, M. A. Arch. Surg., 1939, 39: 247.
7. Clark, E. Am. J. Digest. Dis., 1942, 9: 428.
8. Cole, W. H. Surg. Gyn. Obst. (Internat. Abstr. Surg.), 1938, 67: 31.
9. Comfort, M. W. Minnesota M., 1941, 24: 225.
10. Comfort, M. W., and Priestley, J. T. Proc. Mayo Clin., 1943, 18: 409.
11. Connell, F. G. Am. J. Digest. Dis., 1941, 8: 327.
12. Dozzi, D. L. J. Lab. & Clin. Med., 1940, 25: 1303.
13. Dragstedt, L. R. Ann. Surg., 1943, 118: 576.
14. Dragstedt, L. R., Haymond, H. E., and Ellis, J. C. Arch. Surg., 1934, 28: 232.
15. Edmondson, H. A., and Fields, I. A. Arch. Int. M., 1942, 69: 177.
16. Edmondson, H. A., and Berne, C. J. Surg. Gyn. Obst., 1944, 79: 240.
17. Egdalh, A. Bull. Johns Hopkins Hosp., 1907, 18: 130.
18. Elman, R. Surg. Gyn. Obst., 1933, 57: 291.
19. Idem. Ann. Surg., 1937, 105: 379.
20. Idem. Am. J. Digest. Dis., 1938, 4: 732.
21. Idem. J. Am. M. Ass., 1942, 118: 1265.
22. Fallis, L. S. Ann. Surg., 1941, 113: 1070.
23. Fitz, R. H. Boston M. & S. J., 1889, 120: 181; 1889, 120: 205; and 1889, 120: 181.
24. Gottesman, J., Casten, D., and Beller, A. J. Proc. Soc. Exp. Biol., N. Y., 1942, 49: 365.
25. Halsted, W. S. Bull. Johns Hopkins Hosp., 1901, 12: 179.
26. Johnson, T. A., and Bockus, H. L. Arch. Int. M., 1940, 66: 62.
27. Jones, R., Jr. Am. J. M. Sc., 1943, 205: 277.
28. Judd, E. S., Mattson, H., and Mahorner, H. R. Arch. Surg., 1931, 22: 838.
29. Lahey, F. H., and Lium, R. Surg. Gyn. Obst., 1937, 64: 78.
30. Lewis, D. New York State J. M., 1936, 36: 1015.
31. Mann, F. C., and Girodano, A. S. Arch. Surg., 1923, 6: 1.
32. Mayo, H. R., and Ellis, E. A. Lancet, Lond., 1928, 1: 495.
33. McWhorter, G. L. Arch. Surg., 1932, 25: 958.
34. Moynihan, B. Ann. Surg., 1925, 81: 132.
35. Naffziger, H. C., and McCorkle, H. J. Ann. Surg., 1943, 118: 594.
36. Opie, E. L. Am. J. M. Sc., 1901, 121: 27.
37. Popper, H. L. Am. J. Digest. Dis., 1942, 9: 186.
38. Popper, H. L., and Necheles, H. Surg. Gyn. Obst., 1942, 74: 123.
39. Rich, A. R., and Duff, G. L. Bull. Johns Hopkins Hosp., 1936, 58: 212.
40. Schmieden, V., and Sebening, W. Surg. Gyn. Obst., 1928, 46: 735.
41. Shumaker, H. B. J. Ann. Surg., 1940, 112: 177.
42. Smyth, C. J. Arch. Path., 1940, 30: 651.
43. Somogyi, M. J. Biol. Chem., 1938, 125.
44. Stern, E. L. Am. J. Surg., 1930, 8: 58.
45. Trasoff, A., and Scarf, M. Am. J. M. Sc., 1937, 194: 479.
46. Walker, I. J. N. England J. M., 1938, 218: 376.
47. Wangensteen, O. H., Leven, N. L., and Manson, M. H. Arch. Surg., 1931, 23: 47.

CAUSALGIA

I. The Rôle of Sympathetic Interruption in Treatment

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THE agonizing severity and unrelenting constancy of the pain of causalgia, the resultant disability, and the profound physical and mental strain associated with this disorder constitute a therapeutic challenge of the utmost importance. The recent war afforded an unparalleled opportunity for evaluation of methods of treatment not only because of the large numbers of cases which resulted from combat injuries, but also by virtue of the segregation of patients with such disorders in the Neurosurgical and Vascular Centers where they could be examined and treated under the most favorable circumstances. It is interesting in this regard that a similar concentration of patients with neurological injuries and diseases in the United States Army Hospital at Christian Street in Philadelphia during the Civil War permitted Weir Mitchell and his associates to carry out their monumental study of this condition.

For some time it has been evident to certain observers that interruption of the sympathetic pathways constitutes the most reliable, conservative and safe method of treatment. The recent war experiences which have thus far been reported are in agreement concerning the general efficacy of sympathetic interruption. The decision to add our own experiences to those already recorded has been prompted by several considerations. In the first place, although Spurling's case of relief of pain following sympathectomy was reported 17 years ago, this means of therapy has not found its way into many of the common source-books of learning. Since many of the recent textbooks still present a most pessimistic picture concerning the treatment of causalgia and particularly since they tend to perpetuate an attitude of therapeutic neglect or of resort to surgical procedures unreliable in efficacy and fraught with hazard of persistent disability, it has seemed advisable to bolster the position of sympathetic interruption as the treatment of choice by recording another large series of cases. Second, it has seemed worthwhile to inquire into the constancy of temporary relief of pain from sympathetic procaine anesthesia and, if such relief be invariably found in cases of true causalgia, to attempt to explain the occasional failures or incomplete cures following permanent sympathetic interruption. In the third place we shall try to elucidate the question whether causalgia can ever be cured permanently by one or more procaine blocks of the sympathetic pathways. Though success in certain cases has been reported by some investigators, others (9) state that they have never observed such cures.

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CLINICAL MATERIAL AND METHODS

This study is based upon observations on 90 patients who were thought clinically to be suffering from major causalgia. A few were felt to be atypical in certain respects. Instances of so called minor causalgia, cases of paraplegia with burning pain, and other posttraumatic painful states are excluded. Most of the patients were studied at the Mayo General Hospital, a few at other Army hospitals. Nine of the patients included in this survey have been reported in a previous communication (7). In most instances the patients were followed sufficiently long to permit proper evaluation of the final results. The eventual outcome in a small number of patients is unknown, either because we were unable to follow them long enough or because our records are incomplete.

Study of each patient included a careful inquiry into the nature of the injury, the extent of the motor and sensory dysfunction, the onset, character, and constancy of the pain, as well as factors which either caused exacerbation or amelioration of symptoms. Each patient was given a complete neurological examination, and most of them underwent a careful evaluation of the vasomotor status. Skin temperature studies were carried out in the majority, oscillometric studies in some.

Sympathetic blocks were performed by the introduction of 0.5 per cent procaine with adrenalin into the paravertebral space between the first and second dorsals in the case of lesions of the upper extremity, between the first and second lumbars in lesions of the lower extremity. The efficacy of the injection in blocking the sympathetic pathways was established by such observations as the presence of a Horner's syndrome, cessation of sweating and vasodilatation. Sympathetic ganglionectomy for the lower extremities was accomplished through an anterior extraperitoneal approach under spinal anesthesia. The upper extremities were denervated by the posterior preganglionic operation of Smithwick performed under intratracheal anesthesia. There were no deaths and no serious complications. A single patient was treated by paravertebral alcohol block.

RESULT

Fifty-seven patients were treated by permanent sympathetic interruption. Twenty-one responded well to single or repeated procaine sympathetic blocks. Two patients noted gradual steady improvement following neurolysis, with eventual relief of all symptoms. Two patients obtained relief of pain following excision of a neuroma and neurorrhaphy. In this regard it is of interest that 11 patients who subsequently obtained relief of pain from sympathetic procaine blocks had noted no relief after neurolysis, and 3 had noted no relief after neurolysis and neurorrhaphy. Similarly 13 patients who were benefited greatly by sympathectomy had observed no change in pain following neurolysis, nor had 4 others following neurolysis and neurorrhaphy. In 3 there was a spontaneous subsidence of symptoms. The outcome in 5 patients is unknown. One of the 5 was subsequently treated by sympathectomy and 1 was apparently improving under a course of intermittent venous occlusion when last heard from.

THE EFFECT OF PROCAINE ANESTHESIA

One hundred and eighty-one sympathetic blocks were performed in 83 patients. Excluded are a number of blocks carried out upon some of the patients before they came under our care. Seven patients in the series received no sympathetic anesthesia. Two were patients in whom sympathectomy was felt advisable under any circumstances because of poor circulation in a limb in which there was a large subcutaneously ruptured aneurysm. In another patient sympathectomy was also felt advisable because of extensive nerve damage and markedly impaired circulation resulting from aneurysmorrhaphy with ligation of the brachial artery. Two were patients who obtained relief following neurolysis or neurorrhaphy, and two who were rapidly making a spontaneous recovery at the time of the original examination.

In 5 instances the injection was ineffectual in anesthetizing the sympathetic chain and in relieving pain; in each case other injections were effectual in blocking the sympathetic nerves and in relieving pain. In a few cases relief of pain was incomplete. In some of these the burning pain was relieved completely and the residual discomfort consisted of a persistence of other painful sensations such as tingling or aching. One patient noted very little alteration of pain; he will be referred to more fully later. In the other instances the entire pain was dramatically relieved. In all of medical practice no results are more sudden or spectacular. Before the injection the patient would be in agonizing pain, guarding his injured extremity with zealous care, reluctant to have it examined even after painstaking assurance that every effort would be taken to perform the examination in the gentlest manner, hesitant to have the block itself carried out because he felt that his capacity to suffer prevented him from enduring any more discomfort, even the prick of a needle which he had often heard from other sufferers might lead the way to cure. As soon as the injection

TABLE I.—DURATION OF RELIEF OF PAIN WITH REPEATED PROCAINE SYMPATHETIC BLOCKS IN THOSE PATIENTS SUBSEQUENTLY TREATED BY SYMPATHECTOMY WHO HAD MORE THAN ONE BLOCK BEFORE OPERATION

Case No.	Duration of relief of pain in hours				
	1st block	2nd block	3rd block	4th block	5th block
1	1	1			
2	1	1	1	1	
3	2.5	2	2		
4	3		2		
5	1.5	1			
6	20	4	2		
7	4.5	4			
8	1	1	1		
9	1	1			
10	1	1	1		
11	1	1	1	1	1
12	3	1	1.5		
13	4	1	0.7		
14	1	0.5	1		
15	3	1.5			
16	6 days	2 days	2		
17	2	3			
18	2.5	1.5			
19	1.5	1.5	0.5		
20	2	2	1		
21	0.5	0.3	0.5		
22	2	1	1	1	
23	6	2	2		
24	2	2	2	2	
25	1	1			
26	1	1	1		
27	1.5	1.5			
28	1	1			
29	2 days	1 day	2		
30	2	1	0.7		
31	6	6	6		
32	2	0.75			

was completed his careworn face would assume an expression of extreme satisfaction, the beads of perspiration would disappear, and he would settle back with a sigh of relief to enjoy his respite. Adequate examination which had before been difficult or impossible was now easily performed.

The duration of relief varied. In some instances it lasted only for the period of the anesthesia, while in others it lasted for hours, days, or even permanently. In a few the exact duration of the relief of pain is not recorded. Seventy-eight blocks were followed by relief of pain for 2 hours or more. In the remainder the relief lasted only for the length of the sympathetic anesthesia, 1½ hours or less. It was a very striking finding that in some instances the duration of relief was the same after each block, or grew progressively shorter (Table I). All patients who had such a response were treated by sympathectomy except for the occasional patient who appeared to be getting well spontaneously or was relieved by excision of a neuroma and suture. In some patients, on the other hand, each successive block was followed by a progressively longer period of relief (Table II). These patients in general tended to obtain permanent relief from such treatment. It was a striking finding that in the first group the initial injection tended to be prolonged beyond the period of sympathetic anesthesia. For example, of the 31 cases recorded in Table I in which multiple blocks were carried out before sympathectomy, the original block gave relief of 1½ hours or less in 14, or 42.5 per cent, while the same brief cessation of pain was noted in 21 of the remaining 23 patients (91.3 per cent) who had a single sympathetic anesthesia before sympathectomy. On the other hand, all of the 21 patients listed in Table II who obtained permanent relief from one or more procaine blocks were freed from pain for prolonged periods by the first injection, except for 3 in whom it was felt the sympathetic anesthesia was incomplete. It is also evident from the data in Table I that when relief from the first injection was limited to the period of sympathetic anesthesia, subsequent blocks generally gave no more prolonged respite from pain. When each successive block resulted in a shorter period of relief, no permanent alleviation of pain was achieved by further injections (Table I). On the contrary, those patients who were eventually rendered free of pain by procaine blocks generally noted progressively longer periods of freedom from pain following each successive injection.

TABLE II.—DATA CONCERNING PATIENTS PERMANENTLY BENEFITED BY PROCAINE SYMPATHETIC BLOCKS

Case No.	Nerves injured	Degree of causalgia	Duration of causalgia in mos.	Duration of relief following sympathetic blocks (1)					Remarks
				1st	2nd	3rd	4th	5th	
1	Radial	+++	4	P					Complete relief except for occasional slight dull ache in thumb
2	Sciatic	+++	4	0.2*	12	12	P		Very slight residual pain subsequently relieved by excision of neuroma and neurorrhaphy
3	Brachial plexus	++++	2.5	P					
4	Sciatic	*++	2.5	P					
5	Sciatic	++	7	P					
6	Sciatic	++	9	2	2	P			Each of 1st two blocks resulted in lasting diminuation of pain
7	Ulnar	++++	2	2M	1W	P			Complete relief except for occasional mild twinges of pain
8	Sciatic	+++	3	P					No pain for 3 mos., occasional slight pain thereafter
9	Median, radial, ulnar	++	3.5	2	*	5D	P		
10	Tibial	++++	2	4D	P				Only mild pain after 1st block
11	Brachial plexus	++	4	2	20	2.5M	P		95% relief
12	Sciatic	++++	4	9	0.5	0.5	4D	P	Complete relief except for occasional slight "tickling sensation"
13	Median ulnar	++	7	P					
14	Brachial plexus	++	2	4	P				
15	Median, ulnar	++++	4	P					
16	Radial	++	3	P					
17	Sciatic	++++	6	2	P				
18	Median and lateral plantar	+	4.5	P					
19	Median, radial	++++	4.5	P					Complete relief 4 hrs., then return of very mild pain. Gradual improvement. No pain after 12 weeks
20	Sciatic	++	5	0.7*	4D	P			No pain for 9 days. Very slight residual thereafter
21	Sciatic	++	5	*	P				Very slight residual

(1) Symbols: D—days; W—weeks; M—months; P—permanent. Where no symbol is used the numeral designates hours.
*Injection thought to have resulted in incomplete sympathetic block.

Of the 83 patients in whom sympathetic anesthesia was induced one time or more, 21 obtained permanent relief. The data concerning these patients are recorded in Table II. Ten were cases of causalgia of the upper extremity and 11 of the lower. The severity varied; in 7 cases it was very severe, in 4 moderate, in 9 mild,[1] and in 1 trivial. The pain was of from 2 to 9 months' duration or an average of 4.21 months. Ten required only 1 injection, the remainder 2, 3, 4 or 5 injections. In some of the latter cases the pain was never as severe after the first injection. In 9 patients there was a persistence of very slight discomfort. In 1 of them all pain disappeared 12 weeks later, and another lost his residual discomfort subsequently after excision of a neuroma and nerve repair. In all of the patients the residual pain was trivial in nature and often consisted only of intermittent mild paresthesias. Follow-up observations extended over a number of months in all patients and

[1]In this communication the degree of causalgia has been classified in general as severe, moderate, or mild. Perhaps others would have designated these degrees of pain as excruciating, severe, and moderate. We have used these terms in a comparative way; we do not mean to imply that those classified as "mild" had inconsequential pain but rather that the pain, distressing as it was, was mild in comparison with that apparently suffered by those with more severe grades of causalgia.

for more than a year in some. Altogether the results of sympathetic blocks in these 21 patients must be considered excellent.

RESULTS FOLLOWING SYMPATHECTOMY

Thirty-four patients were treated by permanent interruption of the sympathetic pathways in the upper extremity, 33 by operation, one by alcoholic infiltration (Table III). In 10 cases the brachial plexus was injured, in 10 the median, radial, and ulnar nerves, in 5 the median and ulnar, in 4 the median, in 3 the ulnar, in 1 the radial, and in 1 the radial and ulnar. In 28 cases of the 34 there was injury to the median, and in 29 to the ulnar nerve. In 3 cases the median paralysis was apparently complete and in 5 cases the ulnar paralysis appeared complete. In 11 instances there was associated thrombosis or posttraumatic operative ligation of the major arteries, in 8 involving the brachial, in 1 each the subclavian, the axillary, and the radial and ulnar arteries in combination. In 2 additional patients the brachial artery had been ligated during operative treatment of a brachial aneurysm, while in 2 others there was an aneurysm or arteriovenous fistula, one affecting the axillary artery and the other involving the brachial artery and vein. The causalgia was of extreme degree in 22 cases, of moderate severity in 7, and was mild in 4. The duration of pain at the time of operation ranged from 1.7 to 13 months, an average of 4.7 months. In 25 patients the pain was completely relieved and in 6 others the residual discomfort was inconsequential. In these 31 patients (91 per cent) the result may be said to be excellent. In 2 the result was good in spite of incomplete relief of pain and in only 1 was the operation a failure. These last 3 cases will be presented more fully subsequently. All patients were followed for several months after operation and not a few for a year or more. None had any return of pain or increase in any residual discomfort.

Twenty-three patients were treated by lumbar sympathetic ganglionectomy. The sciatic nerve was injured in 19 patients, once in conjunction with the saphenous nerve. In 1 patient the saphenous nerve was injured, in 2 the peroneal, and in 1 the tibial. Altogether the tibial nerve was partially paralyzed in 15 patients, and apparently completely paralyzed in 3. There was apparent complete peroneal paralysis in 10 patients, partial paralysis in 10. The degree of pain was extreme in 3 patients, moderate in 8, and mild in 12. The duration of pain at the time of operation varied from 3 weeks to 14 months, an average of 5.28 months. The first, second, third, and fourth lumbar ganglia were excised in 4 cases; the first, second, and third in 5; the second and third in 11, and the second, third, and fourth in 3. Relief of pain was complete in 11 patients and in an additional 4 patients an excellent result was obtained, the residual discomfort being trivial. In 3 patients there was mild persistence of pain while 5 had relief only of about half their original pain. These 8 cases with only good or fair results will be discussed more fully subsequently. It is of interest that the result was excellent in 9 of the 11 cases with extreme or moderate pain, and in 6 of the 12 cases with mild causalgia. The result was excellent in 7 of the 9 patients in whom the ganglionectomy included the first ganglion, and in 8 of the 14 in whom the highest ganglion resected was the second.

Of the 57 patients treated by operation (or alcohol injection) an excellent result was obtained in 46, or 81 per cent. In the remainder the relief of pain was satisfactory in all save 1 (Case 22, Table III), although suggestion may have played a part in the cure of 1 (Case 23, Table IV). Altogether the results were excellent in 37 of the 40 patients in whom the pain was moderate or extreme (92.5 per cent) and in 10 of the 17 in whom the pain was mild (58.8 per cent). In the 43 cases in which sympathetic denervation of the entire extremity was complete, an excellent result was obtained in 38 (88.4 per cent) and in 8 of 14 (57.1 per cent) in which the denervation was incomplete (cases of causalgia of the lower extremity in which the first lumbar ganglion was left intact). It would appear profitable to present in more detail the cases in which the result of operation was only good, fair, or poor.

CASE 4 (Table III). This patient was a nurse anesthetist who had sustained a striking blow to her hand, forearm, and arm in a struggle with a patient

TABLE III.—RESULTS OF DORSAL SYMPATHECTOMY IN CAUSALGIA OF UPPER EXTREMITY

Case No.	Nerves injured	Severity of causalgia	Duration of causalgia	Result of treatment
1	Brachial plexus	++++	4	Relief
2	Median, radial, ulnar	+++	7	Relief
3	Median	+++	7	Relief
4	Ulnar	++	6	60% to 80% relief
5	Median	++++	3	Relief
6	Median, radial, ulnar	++++	6	Relief
7	Median, radial, ulnar	++++	5	Relief
8	Brachial plexus	++++	3	90% relief
9	Median, radial, ulnar	+++	4.5	Relief
10	Median, ulnar	++++	7.5	Relief
11	Median, radial, ulnar	++++	2.5	90% relief. Burning disappeared. Mild throbbing and aching off and on
12	Median, radial, ulnar	++++	2.5	Relief
13	Median, ulnar	++++	3	Relief
14	Median, ulnar	++++	2	Relief
15	Median, radial, ulnar	++++	1.7	Relief
16	Brachial plexus	++++	3	Relief
17	Median, radial, ulnar	+++	8	Relief
18	Median, ulnar	++++	4	35% relief. Burning disappeared. Less throbbing Persistence of tingling and aching
19	Brachial plexus	++++	2	Relief
20	Median, radial, ulnar	++	6	Relief
21	Median, radial, ulnar	++	5	Relief
22	Brachial plexus	++++	4	25% relief
23	Radial, ulnar	++++	4	Relief
24	Brachial plexus	++++	4	Relief
25	Median, ulnar	++++	2.5	Relief
26	Brachial plexus	++++	2	Relief
27	Ulnar	+++	6	Relief
28	Radial	+++	4	Relief
29	Median	++++	2	Relief
*30	Ulnar	++++	4	Relief
31	Median	++	6.5	90% relief
32	Brachial plexus	++++	3.5	90% relief
33	Brachial plexus	++	13	90% relief. Occasional intermittent shooting pains persisted
34	Brachial plexus	++++	2	90% relief

*This patient was treated by alcoholic block of sympathetic chain.

during a difficult anesthetic induction. Thereafter progressively increasing signs of ulnar paralysis ensued. Six months after injury the ulnar nerve was explored at the elbow and found to be diffusely thinned and scarred; it was transplanted anteriorly. Little or no improvement in nerve function followed. Four months after the injury she had begun to have intense, constant, burning pain in the hand, largely limited to the ulnar area. This was not influenced by the transplantation of the ulnar nerve. Six months after onset of pain, a sympathetic block gave complete relief for 4½ hours. Another block performed 3 days later gave similar relief for a slightly shorter period. Three days following this injection a preganglionic dorsal sympathectomy was performed. The patient was relatively comfortable

TABLE IV.—RESULTS OF LUMBAR SYMPATHECTOMY IN CAUSALGIA OF LOWER EXTREMITY

Case No.	Nerves injured	Severity of causalgia	Duration of causalgia	Ganglia excised	Result of treatment
1	Sciatic	++	4	2, 3	Relief
2	Saphenous	+++	3.5	2, 3	Relief
3	Sciatic	++++	4	2, 3	75% relief. Burning disappeared. Slight residual tingling and aching
4	Sciatic	+++	6	1, 2, 3	Relief
5	Sciatic	++	4	2, 3	50% relief
6	Sciatic	+++	6.5	2, 3	Relief
7	Sciatic	+++	6	2, 3	Relief
8	Sciatic	++++	3	1, 2, 3, 4	Relief
9	Sciatic	+++	10	1, 2, 3	Relief
10	Sciatic	++	14	2, 3	75% relief. Burning disappeared
11	Sciatic	++	2.5	2, 3	Some residual tingling
12	Sciatic	++	4	1, 2, 3	50% relief
13	Sciatic	+++	5.5	2, 3, 4	Relief
14	Sciatic, Saphenous	++	4	1, 2, 3, 4	Relief
15	Sciatic	++	4	2, 3, 4	50% relief
16	Sciatic	++	10	1, 2, 3	50% relief
17	Sciatic	++	9	1, 2, 3, 4	90% relief
18	Peroneal	++	4.5	2, 3, 4	90% relief
19	Sciatic	+++	0.75	1, 2, 3, 4	90% relief
20	Tibial	++	2	2, 3	50–75% relief
21	Sciatic	++++	1.2	2, 3	90% relief
22	Superficial peroneal	++	10	1, 2, 3	Relief
23	Sciatic	+++	2	2, 3	50% relief. Residual pain at night for 5 weeks. Disappeared with reassurance

thereafter and required no narcotics or sedatives, but occasionally had mild pain. She estimated that she had from 60 to 80 per cent relief. No explanation is offered for the continued mild pain.

CASE 18 (Table III). This patient sustained a shell fragment injury of his forearm. The median and ulnar nerves and, questionably, the radial, were badly damaged; there was a compound comminuted fracture of the radius and ulna; the radial artery was severed and had to be ligated; the ulnar artery was thrombosed. Two days after injury intense constant pain began. He complained of burning, tingling, pins and needles sensations, throbbing, and aching of the entire forearm and hand. Four months later a sympathetic block gave relief for 1 hour. A few days later dorsal sympathectomy was carried out. On questioning the patient he estimated that only about one-third of the pain was relieved. He no longer had any burning pain, however, the throbbing was less, and his residual discomfort consisted chiefly of tingling and aching. His circulation was improved and radial nerve function which had apparently been absent before was now found to be intact. He required no sedation and his appearance was one of comfort in contrast to one of abject misery before operation. This case was atypical in the wide extent of the area in which pain was felt. The fractures were infected and ununited, and part of the remaining pain was due perhaps to movement at the fracture sites. Altogether the result was good.

CASE 22 (Table III). The patient had sustained in a motorcycle accident avulsion of the trunks of his brachial plexus, thrombosis of the subclavian artery, acromioclavicular separation, and fracture of the humerus. The circulation was precarious and he developed ischemic ulcers of the hand. Immediately after injury he complained of extreme burning, aching, mashing, and squeezing pain in his paralyzed forearm and hand, and this continued unabated. Four months after injury an effectual sympathetic block gave relief of pain about the elbow and in the proximal forearm but none in the distal portions of the extremity. In spite of this poor response, sympathectomy was performed the following day in the hope that it would provide relief, because there appeared no hope of saving the limb if the circulation could not be improved, and because there was some question that the nerve paralysis might be ischemic in nature. The pain disappeared from the proximal third of the forearm but was as severe as ever distally.

Subsequent lysis of the plexus brought no relief, nor did alcohol injection of the plexus. It is understood that the entire neuromatous plexus was subsequently excised, but the eventual outcome is unknown to us. The patient was atypical in the wide extent of the area in which pain was felt. The result of the sympathectomy was a failure.

CASE 3 (Table IV). This patient was wounded in the thigh and popliteal space, and sustained also a partial injury of the tibial component of the sciatic nerve. Severe, constant, burning pain in the toes and sole of the foot began immediately. Five sympathetic injections were performed overseas and none altered the pain; it is not known whether sympathetic anesthesia was obtained. Four months after injury a sympathetic block resulted in cessation of pain for 1 hour. Three days later a second and third lumbar ganglionectomy was performed. The burning pain disappeared but he now complained of mild tingling and aching. In contrast to his preoperative state during which he was always in great pain and on the verge of tears, he now appeared happy and comfortable. Five weeks later a neurolysis was carried out with relief of the residual pain. It would appear that the tingling and aching sensations not complained of during the period of excruciating burning came to consciousness with relief from the burning. The result was considered good.

CASE 5 (Table IV). This patient noted immediate onset of mild burning and tingling in the sole and toes following a thigh injury in which the sciatic nerve was traumatized. There was evidence of a complete peroneal and partial tibial paralysis. Three sympathetic blocks performed 2½ months after injury gave relief on each occasion for about half an hour. Excision of a neuroma and partial neurorrhaphy a few days later were without effect upon the pain. Six weeks afterward the second and third sympathetic ganglia were excised. The patient continued to complain of some pain but appeared more comfortable and slept well without narcotics, which had been required previously. That he was making the most of any residual pain was evidenced by these observations as well as by the fact that sterile subcutaneous injections of water now gave relief of pain although they had not done so before operation. He continued to improve. The result was considered good. In this case certain neuropsychiatric features may have been at play in the persistence of some complaints.

CASE 11 (Table IV). The patient had noted the onset of constant mild burning and tingling in the sole and toes 2 weeks following a wound of the thigh with injury of the sciatic nerve. Two sympathetic blocks performed a month later gave relief for 1½ hours on each occasion. A month afterward the second and third sympathetic ganglia were excised. There was no further burning but slight intermittent tingling persisted especially when the patient walked. This discomfort became progressively less, nerve function improved steadily, and when seen 3 months later he was free of all discomfort. The result was considered good. This is an instance of relief of the major pain with persistence of some paresthesias.

CASE 12 (Table IV). Two weeks after an injury to the thigh in which the sciatic nerve was badly damaged, the patient began to have constant knife-like, tingling, shock-like, aching and burning pains in the ankle and sole of the foot. Though he complained bitterly, observation suggested that his pain was mild in comparison with that of most of those with severe causalgia. Cold packs caused exacerbation of pain. A month after injury two sympathetic blocks gave relief for 1 hour on each occasion. A few days later an alcohol injection was made with production of only partial sympathetic anesthesia and with only slight reduction in pain. Sympathectomy was deferred until after neurolysis had been carried out and was then performed somewhat reluctantly because certain features of the case appeared atypical, especially the multiplicity of the types of pain and the lack of preponderance of burning. He had noted no improvement after lysis of the nerve which was badly scarred over such a long extent that excision and suture appeared impossible. Sweating observations after sympathectomy suggested that denervation of the lower extremity was complete. Most of the pain disappeared after sympathectomy and there was little left except a very annoying tingling which was felt especially in the peroneal distribution. He was able to take physiotherapy, to walk with a brace, and his edema disappeared. He slept poorly, however, complained a great deal, and inquired about the feasibility of cordotomy. He was transferred to another hospital and when seen about 2 years later stated that the pain had disappeared after a femoral periarterial sympathectomy had been performed. This would appear to be an atypical case in which some residual paresthesias were particularly disturbing to a patient with a low pain threshold. It is difficult to understand how periarterial stripping could have been effective in a sympathectomized limb.

CASE 15 (Table IV). This patient had sustained a clinically complete sciatic injury from a wound of the thigh. He began immediately to have persistent mild burning, stinging, tingling, throbbing and shooting pains throughout the entire foot. Four months after injury three sympathetic blocks were performed. There was relief of pain for 2, 1, and ¾ of an hour following these injections. A few days later a second, third, and fourth sympathetic ganglionectomy was carried out. Milder intermittent pains of the same character persisted although he felt considerably improved and was able to put weight on his foot and to sleep without sedation, both impossible before operation. The result was felt to be good. One might speculate whether excision of the first lumbar ganglion as well would have resulted in complete cessation of pain.

CASE 16 (Table IV). The patient noted onset of constant, mild, burning and tingling pains in the dorsum of the foot and in the toes immediately following a thigh injury in which he sustained a mild

damage to both components of the sciatic nerve. Nine months after injury he was given three sympathetic blocks, each of which resulted in cessation of pain for a 6 hour period. A month later the first, second, and third sympathetic ganglia were removed He estimated that half his pain was gone. The pain at rest largely disappeared but some mild burning and tingling was felt when he stood or walked. There was no longer any hyperesthesia. He continued to improve. The result was felt to be good.

CASE 20 (Table IV). After an unknown interval following wounds to his thigh and leg the patient developed mild burning pain in the foot. The injury had produced an aneurysm of the popliteal artery which had ruptured subcutaneously before admission. The tense swelling of the popliteal area caused such severe pain as to outweigh entirely the mild pain in the foot. Neurological changes consisted only of hypesthesia of the dorsum and sole of the foot with areas of marked hyperesthesia. Because of poor collateral circulation and the possibility of forced early operation, the second and third sympathetic ganglia were excised 2 months after injury. The pain decreased and the collateral circulation was improved. Three weeks after sympathectomy, aneurysmorrhaphy was carried out. The result of sympathectomy in this patient was considered fair. The burning pain was less after ganglionectomy and was limited to the distal portions of the foot. The hyperesthesia largely disappeared.

CASE 23 (Table IV). The patient noted onset of burning pain in the sole of the foot a few days after a thigh injury which produced a large aneurysm of the profunda femoral artery. Signs of sciatic injury were limited to hyperesthesia of the plantar surface of the foot. Seven weeks after injury aneurysmorrhaphy was carried out. This effected no change in the pain. A few days later a sympathetic block was performed; this gave relief of pain for 2 hours. A second block the following day gave relief for 45 minutes. Three days later the second and third ganglia were excised. He complained of very mild pain off and on. Because certain features suggested an underlying hypochondriasis, suggestive persuasion was instituted. By the end of 2 months he was almost entirely free of pain. Certainly some relief can be attributed to sympathectomy, but it is likely that suggestion played a rôle in the eventual excellent result.

DISCUSSION

As might be anticipated with a disorder so painful, so persistent, and so debilitating as causalgia, almost every conceivable kind of medical, physiotherapeutic, and surgical approach which offered any promise of cure has been tried. Some did no harm other than to allow the disorder to persist indefinitely by failing to relieve pain, with resultant dysfunction of the extremity, wearing down of morale, and not infrequently narcotic addiction. Others, such as section and resuture of the injured nerve, root section, and cordotomy, not only were often attended by failure but were unnecessarily destructive procedures. As experience has increased it has become evident that interruption of the sympathetic pathways constitutes the most reliable and safe method of treatment. Our present study confirms this concept. Although numerous successes following periarterial sympathectomy were reported some years ago, direct attack upon the ganglionated sympathetic chain appears to produce more reliable results in causalgia as in other disorders amenable to sympathectomy.

In the present series of cases there were encountered only 4 instances of relief of pain following neurolysis or neurorrhaphy. In contrast, 31 patients who subsequently noted cessation of pain following sympathetic blocks or sympathectomy had experienced no relief whatsoever after neurolysis or neurorrhaphy. This confirms the general unreliability of operative attack upon the injured nerve. In 15 patients who later had relief of pain from sympathectomy or sympathetic blocks, previous ligation and division of the injured artery had been performed without alteration of symptoms. Two other patients who had relief from sympathetic interruption had noted no alleviation following arterial stripping. These observations confirm the unquestionable superiority of operations upon, or procaine injections of, the ganglionated chain to periarterial sympathectomy. Only 3 patients were noted to undergo spontaneous subsidence of symptoms even though most of the patients were observed months and some a year or more after the onset of causalgia.

The results of sympathectomy were excellent. Over 80 per cent had complete lasting relief of pain or were left with only trivial discomfort. The result in the remainder was satisfactory in all save one, the patients being sufficiently improved so that no further treatment was necessary. In addition to diminution of pain, the local hyperesthesia disappeared entirely or in large part in all of them. In one patient it is not unlikely that encouragement and suggestion may have played a part

in the cure effected. The single case of complete failure was an atypical case with complete neuromatous involvement of the entire brachial plexus.

In those cases in which there was incomplete relief of pain, several considerations must be taken into account. In the first place, observations have been recently recorded (1, 9) suggesting that it may be necessary in some instances to sympathectomize the site of injury as well as the area to which the pain is referred. Four cases have been recorded in which pain was relieved after excision of the first lumbar ganglion after incomplete relief following excision of the second and third ganglia, and 2 cases in which relief was obtained after excision of the twelfth thoracic or the eleventh and twelfth thoracic ganglia after incomplete relief had been obtained following excision of the lumbar chain. It is possible that inadequate sympathetic denervation may have been responsible for the incomplete relief in a few of our patients. Such a theory might be considered, for example, in Cases 3, 5, 15, 16, and 20 in Table IV; in all of them there was persistence of mild pain and in all of them the first lumbar ganglion was left intact. Unfortunately such an explanation is hypothetical since subsequent procaine blocks or operative excision of the first ganglion were not performed because the residual discomfort was so inconsequential. Indeed in one of the cases (Case 5) it appeared fairly evident that certain neuropsychiatric factors were at play. This reasoning is not applicable in Cases 4 and 18 in Table III nor in Cases 12 and 16 in Table IV, since in these patients the area of injury as well as the area of pain was fully denervated.

Without evoking any underlying hypochondriacal or other neuropsychiatric basis, it seems likely that the persistence of mild paresthesias after relief of the principal burning pain is understandable as an increase in conscious appreciation of trivial discomfort to a level not felt formerly when more severe pain of other character was present. Paresthesias of this nature are commonly enough seen in injuries and diseases of nerves unassociated with causalgia. This explanation may serve for the incompleteness of relief in such cases as 18, Table III, and 3 and 11, Table IV. Finally, recognizing full well the hazard of implying that failure of complete cure from any procedure is due to attendant neuropsychiatric factors, we feel that such factors do occasionally contribute to persistence of pain. This appeared to be true in Cases 5, 12, and 23. Indeed, 2 of these 3 patients continued to improve with reassurance, while the third obtained relief of residual discomfort from periarterial stripping in an already sympathectomized extremity.

Though permanent relief of pain in causalgia from sympathetic procaine blocks has been reported, some observers are in doubt that such cures can be effected in true causalgia. In 5 recent papers (1, 2, 3, 6, 9) in which a total of approximately 200 sympathectomies are reported, one author did not mention cures following sympathetic blocks alone, two noted cures in a few patients but stated that repeated blocks generally produced no permanent effect, another stated that repeated blocks were ineffectual in providing complete permanent relief, while the fifth observed prompt or delayed relief of pain of sufficient degree to make unnecessary other treatment in 45 of 91 patients. In our experience single or repeated procaine blocks effected a very satisfactory alleviation of symptoms in 21 of 83 patients in whom one or more injections were made. Our studies confirm the findings we have observed in other vasomotor disorders that there is little likelihood of obtaining lasting improvement from any number of injections if the good response to the first is limited to the period of sympathetic anesthesia. Even more reliably a decrease in the duration of relief with successive blocks suggests that a permanent cure cannot be effected by procaine blocks alone. On the other hand, if the initial injection gives relief prolonged beyond the period of sympathetic anesthesia or if successive blocks result in increasing periods of relief, one should be encouraged to try to effect a permanent cure by means of a series of procaine injections.

SUMMARY

1. Sympathectomy is a safe and generally reliable method of treatment in causalgia.

2. Failures are extremely rare and incomplete cures uncommon. It is suggested that incomplete relief may result from failure to denervate the site of injury as well as the area to which pain is referred, from persistence of paresthesias which are observed in cases of nerve injury without causalgia, and from perpetuation by some underlying neuropsychiatric factors.

3. Sympathetic procaine blocks are not infrequently effectual in relieving the pain of causalgia. There is little likelihood that repeated procaine blocks will bring about permanent relief if the first injection causes cessation of pain only for the duration of the anesthesia or if successive blocks give relief for decreasing periods of time. One should be encouraged to proceed with a course of procaine blocks if the initial injection gives relief prolonged beyond the period of anesthesia or if successive blocks result in increasing periods of freedom from pain.

REFERENCES

1. ALLBRITTEN, F. F., Jr., and MALTBY, G. L. Surgery, 1946, 19: 407-414.
2. GOODMAN, E. N., MESSINGER, W. J., and WHITE, J. C. Ann. Surg., 1946, 124: 204-217.
3. KIRKLIN, J. W., CHENOWETH, A. I., and MURPHY, F. Surgery, 1947, 21: 321-342.
4. MAYFIELD, F. H., and DEVINE, J. W. Causalgia. Surg. Gyn. Obst., 1945, 80: 631-635.
5. MITCHELL, S. W., MOOREHOUSE, G. R., and KEEN, W. W. Gunshot and Other Injuries of Nerves. Philadelphia: J. B. Lippincott Co., 1864.
6. RASMUSSEN, T. B., and FREEDMAN, H. J. Neurosurg., 1946, 3: 165-173.
7. SPEIGEL, I. J., and MILOWSKY, J. L. J. Am. M. Ass., 1945, 127: 9-15.
8. SPURLING, R. G. Arch. Neur. Psychiat., 1930, 23: 784-788.
9. ULMER, J. L., and MAYFIELD, F. H. Surg. Gyn. Obst., 1946, 83: 789-796.

EVALUATION OF TREATMENT OF SLIPPING OF THE CAPITAL FEMORAL EPIPHYSIS

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IN order to evaluate the treatment of the slipping of the upper femoral epiphysis during its various stages, the histories and roentgenograms of 169 patients who had been seen at the University of Iowa Hospitals from 1932 to 1947 were reviewed. Seventy-three patients were selected because of good clinical and roentgenographic follow-up. Fifty-four of these had unilateral and 19 had bilateral slipped epiphyses, making a total of 92 hips. The average follow-up time for this selected group was 2 years and 10 months.

The patients were classified into 5 groups as follows:

1. Preslipping stage—5 patients, 1 with bilateral preslipping.

2. Acute slipping or fracture separation of upper femoral epiphysis—19 patients, 1 with bilateral acute slipping.

3. Chronic slipping with minimal to moderate displacement—31 patients, 4 with bilateral chronic slipping.

4. Chronic slipping with marked displacement—21 patients, 5 with bilateral chronic slipping.

5. Residual deformity of femoral head and neck due to old slipped epiphysis—4 patients, 1 with old bilateral slipping.

Seven patients with bilateral slipping of the femoral head had different types of slipping in their 2 hips and were included as patients with unilateral slipping in 2 different groups. Therefore, they are listed twice in this group classification. Twelve patients had bilateral slipping of similar type and are listed only once.

The age of the patients at the onset of symptoms varied from 11 to 17 years in boys, with an average of 14.1 years; and from 10 to 14 years in girls, with an average of 12.1 years. One boy with bilateral slipping was 20 years of age and 1 girl with unilateral slipping was 25 years of age when they first complained of hip pain. Both patients had deficiency of their pituitary growth factor and the closure of all the epiphyses was greatly delayed. The right hip was involved in 43 patients and the left hip was involved in 49 patients. Fifty-six patients, or 76.7 per cent, were male and 17 patients, or 23.3 per cent, were female.

The end-results were graded as follows:

1. Perfect result—normal or almost normal hip joint and femoral neck contours, full range of motion, and no limp or pain.

2. Moderate distortion of the femoral neck, restriction of internal rotation only, and no limp or pain.

3. Marked distortion of the femoral neck, no internal rotation motion and moderate limitation of other ranges of motion, no, or mild, limp on exertion, and no pain.

4. Marked distortion of the femoral head and neck, marked limitation of hip motion in all directions, limp and pain.

PRESLIPPING STAGE

Five patients, 1 with bilateral hip symptoms, belonged to this group. They usually complained of weakness of the leg, and limped on exertion. Pain usually did not appear until a few weeks later, and then it was present only when the patient stood or walked for long periods of time. This pain was localized in the hip, or radiated into the adductor region of the thigh. One patient never complained of any pain.

On physical examination the most consistent finding was limitation of internal rotation motion. One patient had hip pain and limp, but no limitation of motion. Another patient had marked limitation of active hip motion in all directions. Limitation of internal rotation appeared before any actual anatomical displacement had occurred. This limitation of motion could be due to spasm of the obturator internus and gemellus muscles, which are in

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close proximity to the posterior capsule of the hip joint. Howorth found a certain degree of synovitis in the hip joint in all the patients with preslipping on whose hip an exploratory operation was performed.

The roentgenographic examination showed generalized bone atrophy of minor degree of the hemipelvis and the upper femur on the affected side. This generalized bone atrophy was present only in the patients who had limped or did not use the affected leg at least for a few weeks, and was interpreted by us as disuse atrophy. Widening, irregularity, and fuzziness of the upper femoral epiphyseal line were constant findings. No disalignment between the femoral head and neck could be detected either on the anteroposterior or on the lateral roentgenograms (Fig. 1).

Result of treatment of the preslipping stage.

a. Two patients with unilateral preslipping were given crutches for only a few weeks. One patient had pain and moderate limp for 6 months, but slipping of the epiphysis never occurred (result 1). The other patient sustained a fracture separation of the epiphysis 7 months after onset of symptoms. The femoral head did not die, but the joint space became very narrow 1 year after the acute slipping, resulting in marked limitation of motion in this hip (result 4).

b. Two patients with unilateral preslipping and 1 patient with bilateral preslipping were treated by drilling and pinning. This was done by inserting two threaded Steinmann pins from the outer aspect of the upper femur, through the femoral neck into the femoral head. One of these patients was a 20 year old boy, who had had a supracellar cyst which caused hypopituitarism and which delayed closure of all the epiphyses. The supracellar cyst had been removed. The results obtained in these hips were excellent (result, 4 hips, 1) (Fig. 1, d, e).

Comment: The preslipping stage represents a potential danger, as was demonstrated by one of our patients who sustained an acute separation of the epiphysis 7 months after the onset of symptoms. When the syndrome of preslipping is diagnosed, drilling and pinning of the affected upper femoral epiphysis should be done without delay.

ACUTE SLIPPING OR FRACTURE SEPARATION OF THE UPPER FEMORAL EPIPHYSIS

Nineteen patients, one with bilateral fracture separation of the upper femoral epiphysis, belonged to this group. The patients usually gave a history of mild weakness, limp or pain on exertion in the affected limb of a few weeks' or months' duration before the acute slipping took place. The acute slipping was brought about by direct trauma to the greater trochanter or by a minor fall. In one patient the acute slipping took place while turning over in bed.

Immediately after the trauma the patients had very acute pain in the hip and were unable to move the leg. Weight bearing was impossible. Upon physical examination it was found that the leg was in complete outward rotation, and any attempted motion of the leg was extremely painful. There was marked spasm of all hip muscles. The affected limb was from ½ to 3 centimeters shorter than the normal one.

The acute slipping was followed by a period of 2 to 3 weeks of absolute weight-bearing intolerance. The acute pain and muscle spasm decreased gradually during these weeks, and some degree of free hip motion reappeared. However, the hip remained moderately painful and in outward rotation. Osteoarthritis of the hip joint developed within a few months, with flexion, adduction, and external rotation contractures (Fig. 2).

Anteroposterior and lateral roentgenograms revealed the femoral neck to be completely separated from the femoral head and displaced forward and upward. The contours of the displaced femoral neck were sharply demarcated (Figs. 3, 4, and 5).

Result of treatment of the acute slipping stage.

a. Three patients with unilateral acute slipping were seen from 4 to 22 months after the acute episode. They had had no treatment. The femoral head had not died in any of these 3 hips. However, marginal osteophytes, subchondral cysts, and narrow joint space were evident on the roentgenograms taken on admission (Fig. 2). All patients had pain and limp (results—3 hips, 4).

b. Eight patients with unilateral acute slipping, seen from 1 to 21 days after the acute

Fig. 1. Preslipping stage in the left hip in a 12 year old boy. The patient had limped on the left leg for 5 weeks, but had had no pain. The left lower had been in traction for 2 weeks prior to admission. On examination, the left hip was painless and freely movable, except for complete limitation of inward rotation. The right hip was normal. Drilling of the left upper femoral epiphysis followed by the insertion of one threaded Steinmann pin was performed in October, 1943. The same procedure was done on the right, 1 year later because symptoms of preslipping developed in the right hip. The patient was last seen in May, 1947, and both hips were found to be symptomless and had normal range of motion. a, Direct print of a roentgenogram shows generalized bone atrophy of the left pelvic bone and upper femur. The left upper femoral epiphyseal line is wide and fuzzy. b and c, Lateral roentgenograms demonstrate that slipping of the femoral head has not occurred, but the epiphyseal line is wider and more irregular in the left than in the right. d and c, Roentgenograms taken 2½ years later. The epiphyseal plates are ossified. No slipping ever occurred between the femoral head and neck.

Fig. 2. Roentgenogram of the right hip of a 16 year old boy taken 2½ years after acute fracture separation of the right upper femoral epiphysis. This was not reduced. A plaster hip spica was applied for 2 months. The patient had persistent pain in the right hip and had limped since removal of the plaster cast. Range of hip motion was very limited. Production of osteophytes at the upper margin of the hip joint is seen. The femoral head did not become necrotic.

episode, were treated by closed reduction followed by the application of a plaster hip spica. A closed reduction was also attempted in 1 patient seen 3 months after the trauma.

Complete reduction of the fracture separation was obtained in 2 patients, seen 2 and 3 weeks after the acute slipping. The entire femoral head became necrotic in both instances and it took from 2 to 3 years to become completely resubstituted by new bone. The femoral head flattened and the hip joint space became very irregular (results—1 hip, 3; 1 hip, 4).

Partial reduction of the fracture separation was obtained in 4 patients, seen from 1 to 21 days after the acute slipping. The femoral head became completely necrotic in 2 hips and partially necrotic in the remaining 2 (results—1 hip, 2; 2 hips, 3; 1 hip, 4) (Fig. 3).

No reduction was obtained in 2 patients seen 2 weeks and 3 months after the acute slipping. Necrosis did not appear in the femoral head of the first patient (result—3). Complete necrosis occurred in the latter patient (result—4).

c. Five patients with unilateral acute slipping, seen 1 day to 2 weeks after the acute episode, were treated by closed reduction, followed by drilling and pinning of the upper femoral epiphysis.

The reduction was performed in 4 patients under anesthesia by gradual traction and internal rotation and mild abduction of the affected leg on an orthopedic table. Abrupt maneuvers were not employed. When the anteroposterior and lateral roentgenograms showed complete reduction, a small incision was made over the lateral aspect of the upper femoral shaft. A long drill was inserted several times through the femoral neck into the femoral head in order to perforate the epiphyseal line. Two to three threaded Steinmann pins were then inserted into the femoral neck and head to immobilize the reduced head. A plaster hip spica was applied for 4 to 6 weeks.

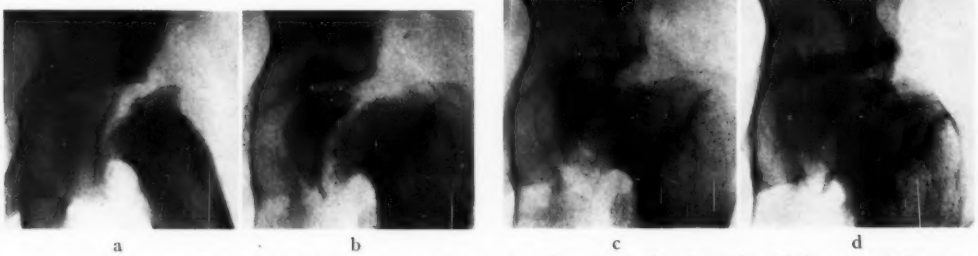

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Fig. 3. a, Roentgenogram of the left hip of a 12 year old boy who sustained a fracture separation of upper femoral epiphysis in July, 1938. The leg was manipulated 3 weeks later, but only an incomplete reduction was obtained; a plaster hip spica was applied. b, Four months after manipulation the femoral head appeared necrotic. An area of absorption of the dead bone is seen in the inferior medial aspect of the head. In April, 1939, a drilling operation of the left femoral neck and head was performed. c, Roentgenogram taken 4 months after the drilling operation shows that the absorption of the necrotic bone was now taking place both from the inner and outer aspects of the femoral head. Evidently, new blood vessels had penetrated through the drill holes into the femoral head. d, Roentgenogram taken 5 years after the fracture separation. The femoral head is seen to be flat and deformed and areas of dead bone are still visible in its center. The left hip was shown to be in marked flexion and adduction contracture and there was very limited range of motion present.

a b c d

Fig. 4. a, Roentgenogram of a 12 year old boy who had a fracture separation of the right upper femoral epiphysis. This was reduced 4 days later by progressive traction and inward rotation on the fracture table with the patient under anesthesia. After the reduction the femoral neck and head were drilled and two threaded Steinmann pins were inserted. b and c, Roentgenograms taken 3 months after reduction show that the fracture displacement had been slightly overreduced. The bone of the femoral head shows areas of irregular density. d, Roentgenogram taken 7 months subsequently shows the femoral head of uniform density and solidly fused to the neck. The patient is symptomless.

Some areas of increased bone density in the femoral head were seen on the roentgenograms taken a few months after reduction in 3 of these hips. These areas disappeared promptly and no damage to the joint or change in contour of the femoral head occurred. The bone of the femoral head of the fourth patient was always of uniform density. A normal hip was the result in each of these 4 patients (result —4 hips, 1) (Fig. 4).

The fifth patient seen 1 day after the trauma was submitted to repeated Leadbetter maneuvers until a perfect reduction was obtained. The femoral neck and head were then drilled and pinned. The femoral head became necrotic and deformed and the joint surface was very irregular (result—1 hip, 4).

d. An 11 year old girl was seen 2 months after the acute episode. The roentgenograms showed a viable femoral head. The hip was exposed by an anterior approach and the epiphyseal plate was drilled. An intertrochanteric osteotomy was performed under direct vision, and the distal femoral fragment was displaced medially under the femoral head. The result was excellent (result—1 hip, 1) (Fig. 5).

A 12 year old girl was seen 4 weeks after the acute episode. The roentgenograms showed that the femoral head was viable. An open reduction of the fracture separation of the epiphysis was performed with a wedge resection of the femoral neck. The entire femoral head became necrotic. The end-result was a deformed and painful hip joint (result—1 hip, 4).

e. Two 15 year old boys were seen 7 weeks and 1 year, respectively, after the acute episode. In the first patient the femoral head was found to be nonviable and was removed at the time of the operation. A fascial hip arthroplasty was performed implanting the femoral neck into the acetabulum. The second patient complained of pain and marked limitation of motion in the hip. A fascial arthroplasty was performed. The end-results were not satisfactory because both patients had some hip pain, limp, and limitation of motion in the affected hip (result—2 hips, 4).

Comment: It is obvious from these statistics that a successful reduction of the acute slipping of the upper femoral epiphysis can be obtained if the patient is seen during the first 2 weeks following the accident. The reduction

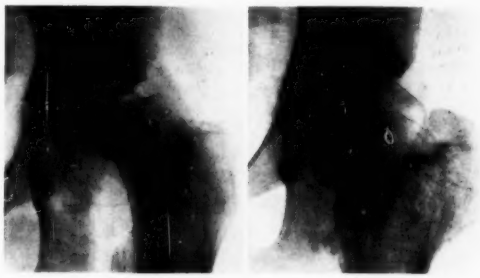

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Fig. 5. a, Roentgenogram of the left hip of an 11 year old girl who had a fracture separation of the upper femoral epiphysis 2 months prior to admission. An intertrochanteric osteotomy was performed through an anterior incision and the epiphysis was drilled. b, Roentgenogram taken 5 months after surgery. The patient was symptomless.

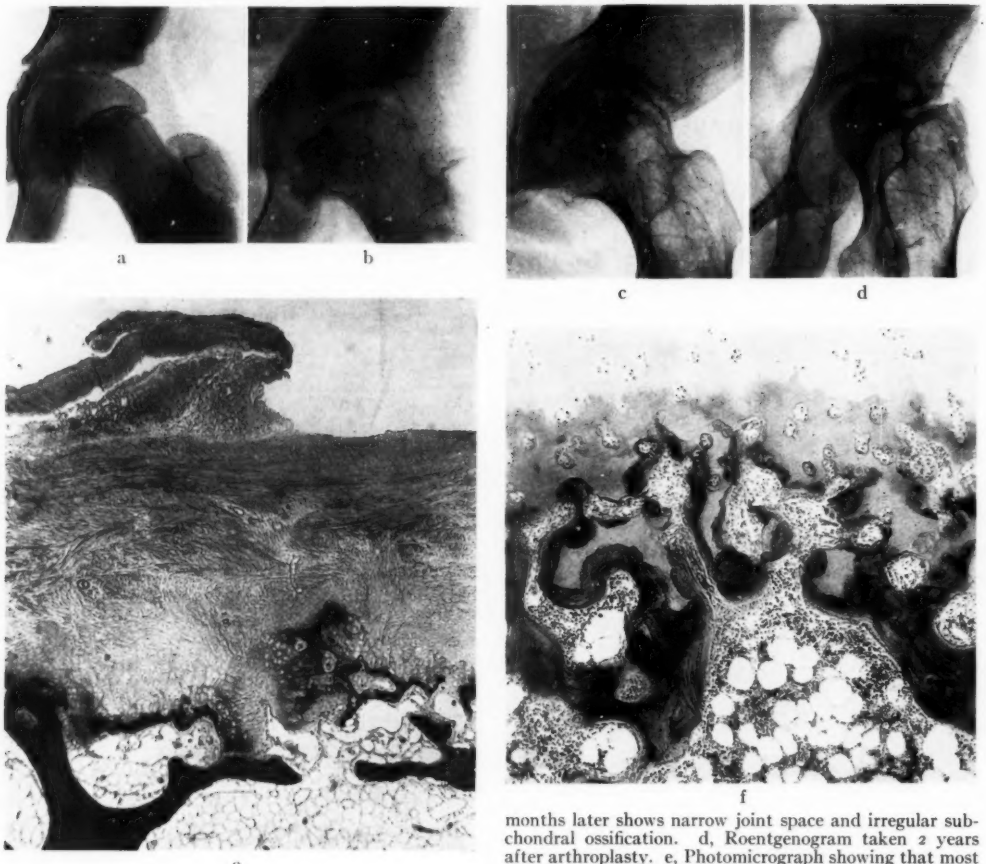

Fig. 6. Roentgenograms of the left hip of a 14 year old boy (see history in the text). a, Normal hip joint. b, Roentgenogram of the same hip taken 1 year later. The joint space is narrow. Mild slipping was demonstrated at the time on the lateral view. c, Roentgenogram taken 14 months later shows narrow joint space and irregular subchondral ossification. d, Roentgenogram taken 2 years after arthroplasty. e, Photomicrograph showing that most of the joint cartilage of the femoral head had been substituted by fibrocartilage. Loose connective tissue is seen attached to the joint surface and represents one of the numerous fibrous adhesions found at surgery. f, Irregular ossification in the deep layers of the joint cartilage of the femoral head.

must be done gently in order to preserve and not further damage the blood supply to the femoral head. The reduction may be accomplished by continuous traction with the patient in bed. It may also be secured by gentle and progressive traction and inward rotation of the affected leg with the patient on the orthopedic table, under general anesthesia. The last procedure was used successfully by us in 4 patients. The reduction must be immediately followed by drilling and pinning of the femoral neck and head. The immobilization of the reduced fracture separation by plaster cast without drilling and pinning gave invariably bad results. Fixation by a bone graft, as advised by Bado, or by bone slivers as advised by Howorth, may be preferable to the use of pins in the reduced acute slipping.

When the patient with fracture separation of the femoral epiphysis is not seen until more than 2 weeks after the accident, no attempt should be made to reduce the slipped epiphysis. Such reduction can be accomplished only with great force, which will, for sure, damage

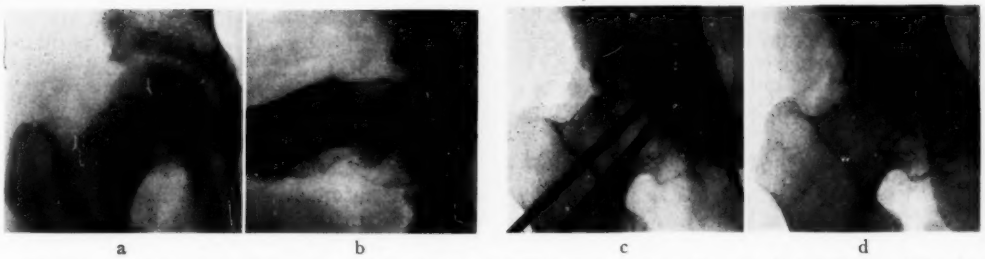

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Fig. 7. a and b, Roentgenograms of the right hip of a 14 year old girl who had a mild degree of slipping of the upper femoral epiphysis. This slipping was treated by drilling and pinning. Very marked stiffening of the hip and narrowing of the hip joint space occurred a few months after surgery. c and d, Described in text.

the blood supply to the femoral head. The statistics on the open reduction show a high percentage of necrosis of the femoral head, which entails a poor result. Very good results may be obtained by the drilling of the epiphysis followed by an intertrochanteric osteotomy performed under direct vision through an anterior approach to the hip joint, with medial displacement of the distal femoral fragment under the head.

CHRONIC SLIPPING WITH MINIMAL TO MODERATE DISPLACEMENT

Thirty-one patients, 4 with bilateral chronic slipping, belonged to this group. The clinical symptoms of these patients were quite similar to those observed in the preslipping stage. However, weakness of the leg, limp on exertion, and pain were usually of intermittent character. Periods of several weeks' or months' duration of complete freedom from symptoms were frequently seen, alternated with periods of pain. Apparently the slipping occurred by repeated displacements of small degree rather than by a continuous and slow process. Several patients of this group had no complaints.

The physical examination revealed marked limitation or absence of internal rotation in all the patients of this group. Some limitation of abduction was also noted in many of them.

The roentgenograms revealed findings similar to those seen in the preslipping stage. In addition, however, the femoral neck appeared widened and shortened and the shadow cast by the epiphyseal plate was very wide and irregular, due mostly to anteversion of the femoral neck. The displacement of the femoral head posteriorly over the neck can be first detected only in the lateral roentgenograms and later on in the anteroposterior views as well (Fig. 7, a and b).

Results of treatment of the chronic slipping stage with minimal to moderate displacement.

a. Six boys with unilateral chronic slipping were seen from 5 months to 2 years after the onset of symptoms. They were given crutches and advised to practice limited weight bearing on the affected leg for a few weeks or months. The slipping did not progress in any of these patients and the end-results were good (results—3 hips, 1; 3 hips, 2).

b. Eight patients with unilateral chronic slipping were seen 1 to 8 months after onset of symptoms. A plaster hip spica was applied from 3 to 8 months, and no, or limited, weight bearing was allowed. No further slipping occurred in any of these patients. The epiphyseal plate became obliterated from 5 to 12 months after onset of treatment, and very good end-results were obtained (results—5 hips, 1; 3 hips, 2).

c. Thirteen patients, 1 with bilateral chronic slipping were seen 1 to 15 months after onset of symptoms. They were treated by drilling and pinning of the upper femoral epiphysis (6) as were the patients of the preslipping group. No attempts were made to reduce the displacement. Plaster cast immobilization was not used after the operation. The epiphyseal plate became obliterated from 4 to 12 months after treatment. The results were excellent (results—11 hips, 1; 2 hips, 2).

A 14 year old girl seen 7 months after the onset of symptoms was treated in the same

manner. The roentgenograms revealed no necrosis of the femoral head, but the joint space became very narrow within a few months after treatment, and the hip motion practically disappeared. This condition will be discussed later (result—4) (Fig. 7).

d. A 17 year old boy, seen 18 months after onset of symptoms, was treated by drilling of the upper femoral epiphysis and intertrochanteric osteotomy. The osteotomy was done to correct an external rotation contracture, and was performed through a lateral approach. The distal femoral fragment was not displaced under the femoral head. The result was not very satisfactory (result—1 hip, 3).

e. A 13 year old girl, seen 10 months after onset of symptoms, was treated by drilling of the upper femoral epiphysis. No internal fixation was used. Four months later the roentgenograms showed the epiphysis to be closed and no further displacement had occurred (result—1 hip, 3).

Comment: In the patients with chronic slipping of minimal to moderate degree good results were obtained by simple rest from weight bearing for a few months, or by prolonged immobilization in plaster hip spica (5), or by drilling and pinning of the upper femoral epiphysis. However, in the patients treated by rest or plaster cast immobilization, an average of 9 months was required before the epiphyseal plate became obliterated. On the other hand, in the group of patients treated by drilling and pinning, the average time for epiphyseal closure was 6 months. Furthermore the fixation of the femoral head to the neck by pinning offers assurance against further slipping and against acute slipping. The patient may be allowed complete freedom of motion following the operation. Weight bearing on the affected leg can be started 1 month after surgery.

CHRONIC SLIPPING WITH MARKED DISPLACEMENT

Twenty-one patients, five with bilateral chronic slipping, belonged to this group. The clinical symptoms of these patients were similar to those seen in the chronic slipping with minimal to moderate displacement, although the limitation of internal rotation and abduction of the hip were more pronounced in patients of this group. The roentgenograms showed the displacement to be more pronounced than in the patients of the preceding group.

Results of treatment of chronic slipping with marked displacement. a. Nine patients with unilateral chronic slipping of marked degree, seen 1 month to 3 years after onset of symptoms, were treated by a short period of bed rest or with crutches and no weight bearing of the affected leg for a few weeks. To this group belonged the case of a 25 year old girl with marked hypopituitarism and delayed closure of all epiphyses (results—7 hips, 3; 2 hips 4).

b. Three patients, one with bilateral chronic slipping of marked degree, seen 9 to 12 months after onset of symptoms were treated by plaster cast immobilization for 4 to 6 months. No further slipping was noted in the hip of any of these patients. The results were satisfactory because the pain disappeared in all the patients so treated (results—4 hips, 3).

c. Two patients, seen 18 and 24 months after onset of symptoms, were treated by manipulation of the hip under anesthesia, followed by plaster cast immobilization. No reduction of the slipping was obtained in either case, and no necrosis of the femoral head was observed. Two years after the manipulation it was noted in one of these patients that the joint space was very narrow and there was great restriction of all hip motions. This case will be discussed later (results—2 hips, 4).

d. Three patients with unilateral chronic slipping of marked degree, seen 6 to 12 months after onset of symptoms, were treated by drilling and pinning of the upper femoral epiphysis. One of these patients was a 20 year old boy who had hypopituitarism with delayed epiphyseal closure. His other hip was treated for a preslipping. The result in each of these patients was satisfactory although they had moderate residual limitation of hip motion (result—3 hips, 3).

e. Eight patients with unilateral chronic slipping of marked degree, seen 6 months to 4 years after onset of symptoms, were treated by different types of osteotomies.

A cuneiform osteotomy of the neck of the femur was performed in one patient, who was seen 3 years after onset of symptoms. The result was poor (result—4).

Three patients were treated by intertrochanteric osteotomy performed through a lateral approach. The results were satisfactory in 2 patients, but poor in the remaining 1, (results—1 hip 2; 1 hip, 3; 1 hip, 4).

A subtrochanteric osteotomy was performed in 4 patients (result—3 hips, 3; 1 hip, 4).

f. Two patients with unilateral chronic slipping of marked degree, seen 1 year and 1½ years respectively after onset of symptoms, were treated by arthroplasty of the hip joint. One had a fascial arthroplasty with a fair result (result—3). The other patient had a cup arthroplasty with a poor result (result—4).

Comments: According to our experience, the prognosis of patients with an advanced degree of chronic slipping is poor under any form of treatment. Plaster cast immobilization or drilling and pinning will prevent further displacement, but an osteotomy will be necessary to correct the distorted femoral head and neck. All the osteotomies in the patients of this group were performed through a lateral incision, and a good alignment of the upper femur was not obtained in any instance. A well performed cuneiform osteotomy of the femoral neck will restore the alignment of the femoral head and neck. However, it greatly endangers the blood supply to the femoral head, "by tearing or cutting the shortened retinacular vessels, or by strangulating them through tension" as pointed out by Greene and by Moore (2, 4). An intertrochanteric osteotomy performed under vision through an anterior incision, with medial displacement of the distal femoral fragment under the femoral head, may offer better results.

RESIDUAL DEFORMITIES OF THE FEMORAL HEAD AND NECK DUE TO OLD SLIPPED EPIPHYSIS

Four patients, one with bilateral hip deformity due to an old slipped epiphysis, belonged to this group. All these patients complained of arthritic type of hip pain and had marked limitation of hip motion. Contracture deformities were found in each involved hip. The roentgenograms revealed coxa vara and coxa anteverta with narrow and some what irregular joint space, marginal osteophytes and deformed femoral head.

Arthritic type of hip pain was the first symptom noticed by a 17 year old boy, whose roentgenograms revealed a mild degree of slipped epiphyses in both hips of long standing. A 29 year old man stated that when he was 15 years of age he had pain in one hip and had limped for a few months. This episode was followed by a symptom-free interval of 14 years. The other patients, 19 and 23 years of age, had chronic hip pain of arthritic character of 4 and 7 years' duration, respectively. These two patients had never been free from pain since the onset of the slipping of the femoral head.

CASE REPORTS

Three patients presented marked narrowing of the joint space following slipping of the upper femoral epiphysis. This phenomenon had been previously mentioned by Moore (5). Because of the rarity of this condition the history and findings in these patients are presented in some detail.

CASE 1. A 14 year old boy was admitted to clinic December, 1935, complaining of progressive limp, pain, and stiffness of the right hip of 5 months' duration. On admission he had only 10 degree range of flexion extension motion. The right hip was in marked external rotation. The roentgenograms revealed a marked degree of chronic slipping in the right hip with a narrow joint space. The left hip was completely normal (Fig. 6,a). The right hip was manipulated under anesthesia, but no reduction of the slipping was obtained. A plaster hip spica was applied for 1½ months. The femoral head did not become necrotic. The roentgenograms taken 6 and 12 months later showed marked irregularity of the subchondral line and progressive thinning of the joint space in both hips. Only a minimal slipping occurred in the left hip. However, the motion in this hip became very restricted 1 year after admission (Fig. 6,b).

Two and one-half years after admission the range of motion in the right hip improved and the joint space, although irregular, appeared wider. However, a flexion and adduction contracture developed in this hip necessitating a subtrochanteric osteotomy 1 year later. On the other hand the left hip remained very stiff and the roentgenograms showed persistent thinning of the joint space, due to new bone formation in the deep layers of the joint cartilage covering the femoral head (Fig. 6,c). A marked flexion and abduction contracture developed in this left hip. A

fascial arthroplasty was performed in May, 1939. At the operation the articular cartilage of the femoral head was found to be eroded and pitted. This condition was most pronounced in the region of the fovea centralis. Numerous fibrous adhesions were present and probably were the cause of the marked limitation of motion. Microscopic examination revealed hyperemia of the synovia which contained a few chronic inflammatory cells. Irregular enchondral ossification was present in the deep layers of the joint cartilage covering the femoral head. Some degree of this same process was present in the cartilage covering the acetabular cavity. The joint cartilage was thinned because of ossification of its deeper layers. The marrow spaces of the subchondral bone contained essentially normal marrow which was devoid of inflammatory cells (Fig. 6,e and f).

The patient was last seen in February, 1947, and had fairly good range of useful motion in both hips. The joint space of the right hip was wide, but the contours of the femoral head were irregular.

CASE 2. A 14 year old girl was admitted to hospital in September, 1945. The entrance complaint was limp and pain in the right hip, aggravated by wet weather, of 7 months' duration. Examination revealed fairly good range of motion in the right hip, except for absent internal rotation. Marked atrophy of the upper femoral metaphysis was seen on the anteroposterior roentgenogram, and the lateral view revealed a mild posterior displacement of the femoral head (Fig. 7,a and b). The right upper femoral epiphysis was drilled and pinned in December, 1945, without any previous hip manipulation. Four months after the operation the range of motion became very restricted, and the roentgenograms showed marked narrowing of the joint space. The femoral head appeared normal. Sedimentation rate, white blood count, hemoglobin, and other laboratory examinations were completely normal. The narrowing of the joint space and the limitation of motion progressed and in December, 1946, the right hip was fixed in a position of 40 degrees' flexion. The roentgenograms at that time showed a very irregular subchondral line with spreading ossification into the deep layers of the joint cartilage of the femoral head (Fig. 7,c). The threaded Steinmann pins were then removed and the hip was gently manipulated under anesthesia; only 30 degrees of flexion extension motion were possible. The patient was last examined in May, 1947, when only a few degrees of flexion extension motion could be detected in the right hip joint (Fig. 7,d). The left hip has always been completely normal.

CASE 3. A 15 year old boy was first admitted to hospital in August, 1942, in this clinic. The entrance complaint was pain and limp in the right hip of 3 weeks' duration. The patient had only 35 degrees of active flexion in the right hip. Passive motion was almost normal. Roentgenograms showed a preslipping of the right femoral epiphysis. The patient was advised to use crutches and limit weight bearing on the affected limb. Seven months later an acute slipping occurred in the right hip. The patient was not seen until 5 months after the accident, when the right hip was manipulated under anesthesia. The position of the displaced head was not changed during the manipulation. Necrosis of the femoral head did not occur. One year later there was marked limitation of motion in the hip joint with irregularity of the subchondral line of the femoral head and acetabulum and marked thinning of the joint space. An intertrochanteric osteotomy was performed to correct flexion and external rotation contracture which had developed in the right hip joint. The patient was last seen 3 months later, in September, 1944, when the examination revealed very limited motion in the right hip joint. The left hip was clinically normal but the roentgenograms taken on the last admission showed marked narrowing of the joint space in both hips.

We have been unable to determine the nature of the process responsible for the symptoms described in these 3 patients. In only one case was material for histological examination obtained when the process was quiescent. The lesions resembled the quiescent stage of a mixed type of arthritis.

SUMMARY

Seventy-three patients with "slipped" upper femoral epiphysis seen at the University Hospital in Iowa City from 1932 to 1947 have been reviewed. Nineteen patients had bilateral slipped epiphyses.

This series of patients was divided into 5 groups, as follows:

1. Preslipping stage—5 patients, 1 with bilateral preslipping. This potentially dangerous stage was treated best by drilling and pinning as soon as the diagnosis was established.

2. Acute slipping or fracture separation of upper femoral epiphysis—19 patients, 1 with bilateral acute slipping. Best results were obtained by early and gentle reduction of the fracture separation, maintaining the reduction by 2 or 3 threaded Steinmann pins. A bone graft used to maintain fixation may be preferable. It is advised that when these patients are seen more than 2 weeks after the accident, no attempts should be made to reduce the slipped epiphysis. An intertrochanteric osteotomy may give good results in these cases without damaging the blood supply to the femoral head.

3. Chronic slipping with minimal to moderate displacement—31 patients, 4 with bilateral chronic slipping. Rest from weight bearing or plaster cast immobilization gave good results; the epiphysis closed on an average of 9 months. Drilling and pinning of the upper femoral epiphysis offered assurance against further slipping or acute slipping; the epiphysis closed on an average of 6 months and the patients had free use of the extremity 1 month after the operation.

4. Chronic slipping with marked displacement—21 patients, 5 with bilateral chronic slipping. The prognosis in this type is poor under any form of treatment. This should be directed first toward preventing further slipping and hastening fusion of the epiphysis. Neck osteotomy will restore the alignment of the femoral head and neck, but loss of blood supply to the femoral head is too frequently the price. Better results may be obtained by drilling the upper femoral epiphysis followed by an intertrochanteric osteotomy performed under vision through an anterior incision with rotation and displacement of the distal fragment medially.

5. Residual deformities—4 patients, 1 with old bilateral slipping.

The clinical symptoms, physical and roentgenographic findings, and results of various types of treatment in these groups are recorded.

Three patients developed early and marked narrowing of the joint space and are presented in some detail. A fascial arthroplasty was performed in one of these patients. The specimen obtained at operation revealed lesions similar to the ones seen in the quiescent stage of a mixed type of arthritis. No evidence of inflammation was noted.

REFERENCES

1. Bado, J. L. Personal communication.
2. Green, W. T. Arch. Surg., 1945 50: 19.
3. Howorth, M. D. Surg. Gyn. Obst., 1941, 73: 233.
4. Moore, R. D. Surg. Gyn. Obst., 1943, 80: 199.
5. Ibid., 1945, 80: 324.
6. Wilson, P. J. Bone Surg., 1938, 20: 379.

SELECTION OF OPERATIVE PROCEDURE TO AVOID COLOSTOMY IN CARCINOMA OF RECTUM AND RECTOSIGMOID

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ABOUT 1710, Littre (26) suggested the establishment of a bowel opening above the complete congenital rectal stricture in infants. Sixty years later, Pillore (1776) performed a cecostomy for a carcinomatous rectosigmoid stricture (26). The real birth of colostomy, however, was in 1783 when Duret (26) successfully performed a left iliac-lumbar colostomy for an imperforate anus in a 3 day old infant.

The abdominal colostomy was not used in connection with operations for extirpation of malignant lesions of the rectum or rectosigmoid until 100 years later when in 1887 Shede actually performed a preliminary colostomy before excising a tumor posteriorly and reestablishing bowel continuity.

From the time of Lisfranc's restricted excision of the rectum in 1826 until Miles presented his technique in 1908, the objective of the operation for this type of cancer was extirpation of the tumor and anastomosis of the remaining anorectal segments to preserve the sphincter mechanism. Numerous techniques for excising these tumors were described, and the emphasis was placed on the methods of approach, i.e. perineal, sacral, anal or vaginal, and the degree of removal of the sacrum. During these years, the sphincter mechanism was frequently excised along with the rectal tumor when the tumor encroached upon the anal sphincter. Among the many names appearing in the literature, Kraske and Hochenegg refer to two types of procedures which have become most familiar, more because of the method and the place of presentation than upon their originality or singularity.

The Kraske procedure is an end-to-end anastomosis of the sigmoid or rectum to the rectum or anus through a posterior approach without an abdominal colostomy. The Hochenegg method is based on the principle of pulling the upper segment out through the anus and fixing it with sutures.

During these years, permanent abdominal colostomy was rarely done for operable cancer of the rectum. It was not accepted as a temporary procedure, antecedent or supplementary, for posterior extirpation and anastomosis because the closure of a temporary colostomy was then accomplished by end-to-end anastomosis and carried a high mortality rate.

The early combined abdominal dissection and perineal excision as presented by Maunsell in 1892 was an operation with sphincter preservation and posterior anastomosis.

In 1908, Miles modified the entire objective for operations on cancer of the rectum and rectosigmoid by minimizing the necessity for retaining the sphincter mechanism and emphasizing the desirability for a radical removal of all contiguous tissue and lymphatics including the anal sphincter. His premise was based on the studies of the lymphatics of the rectum and rectosigmoid by Poirier, Cuneo, and Delamere, from which he concluded that cancer in this region extends upward, laterally and downward. To reduce the incidence of recurrence of carcinoma, wider extirpation of the bowel and associated lymphatics was necessary. This presentation aroused enthusiasm for a more radical operation including the removal of the sphincter, and propaganda about the compatibility of an abdominal colostomy with routine social, economic, and athletic activities. Gradually the abdominal colostomy and combined abdominoperineal excision with removal of the rectosigmoid, rectum, and anus in one or two stages became the accepted procedure. It adheres to the principle of wide local excision and removal of the area of possible lymphatic spread.

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Nevertheless, during the past 35 years in which this operation has become so widely accepted, there have been sporadic attempts to develop operative procedures that would sufficiently answer the need for wide excision and yet preserve anal continence. This has been particularly true where the lesion was situated in the lower sigmoid or rectosigmoid junction. Lockhart-Mummery in 1908 and Balfour in 1910 reported their experiences with anastomosis over a rectal tube.

A new drive for eliminating the permanent colostomy was initiated in 1935 by Devine, who presented a technique for colostomy of the transverse colon which would completely defunction the distal colon, permitting later resection and anastomosis followed by closure of the colostomy. No doubt the principle of this procedure is sound but the operation was not widely accepted, and with the new antibiotic agents of recent years it will probably become less popular.

In 1937, Horsley presented his technique for resecting the rectosigmoid which consisted of a preliminary cecostomy and an open anastomosis deep in the pelvis. Since 1939, reports of cases of re-establishment of bowel continuity and preservation of the anal sphincter have come from Arnold, Bacon, Babcock, Dixon, Dunphy, Fallis, Murray, and Wangensteen. The individual techniques, the indications for, and selections of, cases have varied, but their writings exhibit a common desire to escape the permanent colostomy.

Previous to 1941 I had occasionally restored intestinal continuity with lesions of the lower sigmoid, but never if the lesion involved the rectosigmoid. During the year 1941 and early months of 1942, I anastomosed the terminal ileum to the mid or lower rectum in 7 cases. This operation of ileorectostomy was done because with wide excision of the upper sigmoid at that time it was impossible to anastomose the colorectal ends low in the pelvis. Of these 7 patients, 3 established fairly satisfactory bowel habits even though the terminal ileum emptied directly into the mid or lower rectum. In 4 of the cases with anastomosis to the lower rectum, there was a troublesome diarrhea. This procedure has been discontinued except in cases of multiple polyposis with

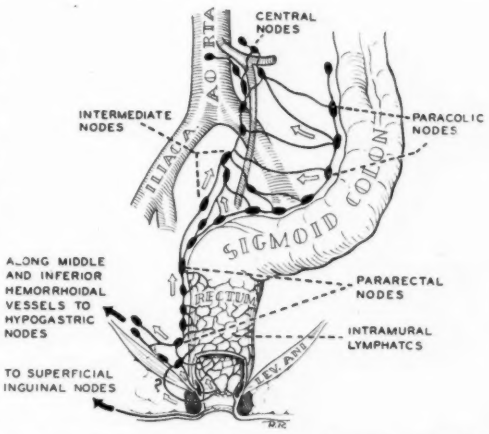

Fig. 1. In the anal canal, 3 modes of spread are considered. The anal skin is drained by lymphatics leading to the superficial inguinal nodes. Above the skin margin is an intermediate area which may drain laterally to under surface of the levator ani and then through this muscle to the hypogastric nodes or directly upward into intramural lymphatics. The upper anal canal and lower rectum may drain into the hypogastric nodes or progress upward along the pararectal nodes. Observations suggest that pararectal and paracolic nodes tend to drain into the intermediate nodes but if these become blocked, the spread is likely to be directly upward along the paracolic nodes.

rectal cancer. The more recent interpretation of lymphatic spread has resulted in a less radical excision of the sigmoid colon and rectum which permits end-to-end anastomosis deep in the pelvis.

Can we conform to the principle of radical cancer surgery in carcinoma of the rectum and rectosigmoid and still preserve the sphincter mechanism? This requires some modifications of Miles' interpretation of the mode of spread —namely upward, laterally, and downward. A challenge to Miles' teachings is supported by the study of lymphatic glands in surgically removed specimens and in autopsies by Westhuer; Gabriel, Dukes, and Bussey; Gilchrist and David; and Coller, Kay, and McIntyre. These studies reveal that dissemination of cancer cells in a downward direction is unusual unless the lymphatics above the tumor are blocked by metastasis. Intramural spread of cancer cells below the lower margin of the tumor is a rarity and studies by the aforementioned investigators suggest that a clearance of at least 1 inch, and preferably 2 inches, is a

Fig. 2. Rectum dissected free and clamps applied. With angled knife, the rectal segment is transected. This should be at least 1 inch below lower margin of lesion and preferably 2 inches.

safe margin. In tumors situated 1 to 3 inches from the anal margin, it is believed that lateral spread over the levator muscle is a possibility and partial excision of this muscle and adjacent tissue is indicated. In upward spread cancer cells travel through some intermediate glands before reaching the glands at the junction of the left colic artery and superior hemorrhoidal artery. There is very little tendency to spread along the marginal vessels of the sigmoid until intermediate or central lymph gland groups have been invaded and have blocked the usual pathway. If we accept this theory of malignant cell extension, it is not necessary to excise the entire upper sigmoid in carcinoma of the rectum and rectosigmoid (Fig. 1). Likewise, with such limited downward and lateral extension, it would seem logical that the lower rectal segment and anal sphincter could be preserved in many cases.

At the present time, we believe that complete abdominoperineal excision is definitely indicated in three different groups of cases. We consider that widespread involvement of mesosigmoid glands or sigmoid wall, requiring unusually high amputation of the sigmoid, is a definite indication for complete abdominoperineal excision because it is impossible to free sufficient colon for anastomosis. Usually in these cases, the intermediate and central glands are heavily laden with metastatic malignant cells forcing travel along secondary lymphatic pathways or retrograde spread. In a few such cases, the terminal ileum has been anastomosed to the lower rectum, a procedure which has been mentioned and will be discussed in a later paper. A second definite indication is when the lesion encroaches upon or involves the sphincter muscles. A third, debatable indication is when the lower margin of the lesion is situated less than 3 inches from the anorectal line. However, intestinal continuity has been restored where a small tumor was located at the 2 inch level. If the tumor is large, completely encircles the rectal canal and the lower margin is at the 3 inch level with definite evidence of invasion through the muscular wall, it is our opinion that complete abdominoperineal excision should be done.

In cases which do not fall into the above groups, the less radical excision which permits

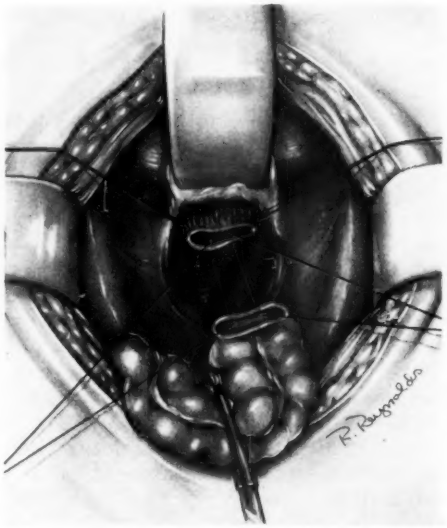

Fig. 3. The lateral catgut sutures replace the two short crushing clamps and support the rectal stump in the pelvis. The two guide sutures, when tied, invert the posterior rectal wall. (Lately we have been inserting four sutures.)

re-establishment of bowel continuity is usually attempted. Three types of operative procedures have been selected to permit sphincter preservation. These are abdominal dissection, resection and anastomosis; abdominal dissection with perineal resection and anastomosis; and perineal dissection with perineal resection and anastomosis.

THE ABDOMINAL DISSECTION WITH RESECTION AND ANASTOMOSIS

The abdominal dissection with resection and anastomosis is selected when the upward spread is limited as heretofore discussed and the lower margin of the lesion is at least 7.5 centimeters (3 inches) from the anal margin. The actual lower margin of the tumor frequently varies from the preoperative estimate by rectal examination. The sacculated structure of the rectum permits elongation of the rectum when pulled upon from above and as the operation progresses the lesion may actually be several centimeters higher than was anticipated. Again one should not always depend on this sacculation resulting in an elevation of the lesion. If we are to play safe,

Fig. 4. The posterior sutures have been tied. One anterior catgut suture with knot on mucosal wall to initiate inversion has been inserted. Remaining sutures will be figure-of-8 or mattress silk sutures.

Fig. 5. A single layer of interrupted figure-of-8 or mattress silk sutures complete the anastomosis.

with our present knowledge of cancer extension in this region, the rectum should be resected at least 2.5 centimeters (1 inch) below the lower margin of the tumor, and we feel that 3.5 centimeters (1½ inches) to 5 centimeters (2 inches) is preferable, even though in low lying lesions this may impede anastomosis from within the abdomen. An open type of anastomosis has been used because in lesions below the lower sigmoid, the difficulties with closed anastomosis seem greater than the advantages. A technique has been developed which has served well. Just before the operation is started, a large rubber catheter, which has been attached to the suction machine, is inserted into the rectum to make sure that it is empty. After the usual study of the vascular pattern, the superior hemorrhoidal vessel or its branches are properly ligated to assure adequate vascularization of a sufficient upper segment of sigmoid to permit anastomosis. However, one must remove an adequate zone of probable lymphatic spread or extension. It is usually necessary to divide the middle hemorrhoidal vessels, yet there appears to be adequate vascularization of the lower rectal stump as noted by bleeding from the rectal wall. A right angle clamp is applied (Fig. 2) at

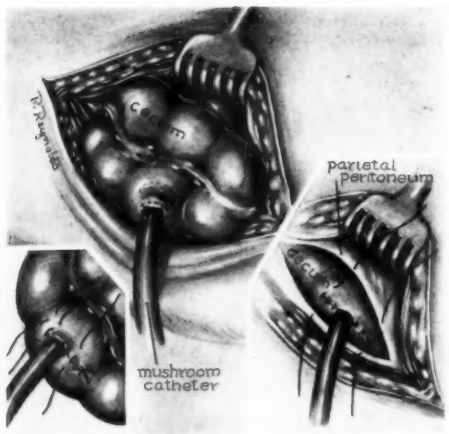

Fig. 6. A supplemental cecostomy by pursestringing a mushroom catheter into the cecum. The cecal wall is inverted and the cecum fixed to the parietal peritoneum.

least 2.5 centimeters (1 inch) below the tumor margin and preferably 4 to 5 centimeters (1.5 to 2 inches). Two short-nosed right-angle clamps grasp either side of the rectal wall just below the right-angle clamp. The rectum below the crushing clamp can then be severed with an angled knife without too much difficulty. At a level high enough above the tumor to be above the level of direct lymphatic spread and through viable sigmoid, a soft-bladed clamp is applied or a rubber drain or tube is clamped or tied around the bowel. This is done several inches or more above the level of transection in order to permit open anastomosis low in the pelvis. After the bowel segment with the tumor is removed, the remaining clamps on the lower segment are replaced by two long catgut sutures. These are permitted to hang over the pelvis to steady the rectal stump. The two ends of the bowel are prepared for bringing into apposition by inserting a long catgut suture on either side of the midline (Fig. 3) in the posterior aspect. The ends of the bowel are guided along these sutures to the juxtaposition, and as these sutures are tied with knots on the mucosal side, the rectal and sigmoidal walls are inverted. A similar catgut suture is placed anteriorly (Fig. 4). The anastomosis is then secured by accurately placing a single layer of interrupted figure-of-8 silk sutures (Fig. 5). A rubber Penrose drain is placed in the hollow of the sacrum and the peritoneal margin of the pelvic floor is approximated above the drain and around the sigmoid at a level above the line of anastomosis.

Before the abdomen is closed, a modified Gibson cecostomy (Fig. 6), using a mushroom catheter, is accomplished through a small muscle-splitting incision on the right side. It is our observation that a patient is more comfortable with a cecostomy tube for decompression than with nasogastric or nasointestinal suction, and probably a cecostomy is a much more efficient safety factor in colon anastomosis. In my experience, this type of cecostomy has always closed spontaneously if obstruction is not present.

The patient is then turned over on his left side, a small incision is made along the coccyx through the fascia propria into the space in the hollow of the sacrum to permit delivery of the previously placed rubber drain.

Placing the sutures deep in the pelvis is quite difficult and awkward and not infrequently there must be some failure in the suture line. However, we must not be too disturbed about this because certain experiences in rectal injuries during World War II substantiate the fact that proper healing will oc-

Fig. 7. The abdominal dissection has been completed and the pelvic peritoneum is loosely closed around the sigmoid. Abdominal incision is closed and the sigmoid and rectum are pulled out of a posterior incision.

cur. It was found that in rectal injuries by single or multiple shell fragments, life would be saved and rectal healing would usually take place if the fecal contents were diverted by a colostomy and proper posterior drainage of the perirectal space in the hollow of the sacrum was established. Although cecostomy does not completely sidetrack the bowel contents, suction applied to the tube and proper posterior drainage have given excellent results. The amount of posterior drainage has varied. At times it is minimal, and again there may be considerable drainage with a fecal odor or even frank feces. Generally the tracts have closed within a week or two, although in 2 cases closure took several months.

ABDOMINAL DISSECTION WITH PERINEAL RESECTION AND ANASTOMOSIS

A second type of operative procedure may be indicated when the lower margin of the tumor is at or just below the 7.5 centimeter (3 inch) level. Also, it may be suspected before operation and confirmed at the operating table that the anastomosis could not be completed from within the abdomen because of a small pelvis. In this event, the abdominal dissection is carried out in the usual manner but the rectum is not transected. It is determined that sufficient viable sigmoid remains to be brought down for anastomosis and the level of transection is labelled by a small black suture. The peritoneum of the pelvic floor is closed, but not too snugly, around the sigmoid. A Gibson type cecostomy is established, the abdomen is closed, and the patient is placed in the prone position with hips elevated, or placed in the left lateral Sims' position. An incision is made over the sacrum and coccyx, the coccyx is excised, and the sigmoid and tumor are delivered (Fig. 7). Sufficient further dissection is done to permit adequate transection below the lower margin of the tumor. A soft-bladed clamp is applied above the level of the identifying black suture. A crushing clamp is applied below this and the sigmoid is severed. Another crushing clamp is applied an inch or more below the tumor margin. Several Allis clamps steady the lower segment as the rectum is severed below the crushing clamp. The lower stump is swabbed out with sulfanilamide solution. The end-to-end anastomosis is accomplished by inserting interrupted catgut sutures in such a manner as to leave the knots on the inner or

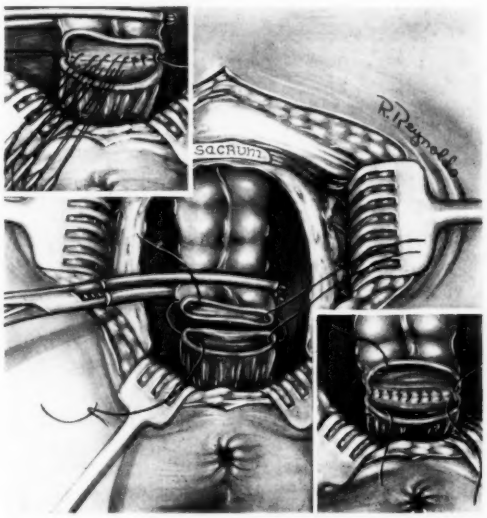

Fig. 8. Posterior anastomosis with inner row of interrupted catgut sutures. To facilitate procedure, all posterior sutures are inserted and then tied.

Fig. 9. Completion of posterior anastomosis. An outer layer of interrupted silk mattress or figure-of-8 sutures is inserted.

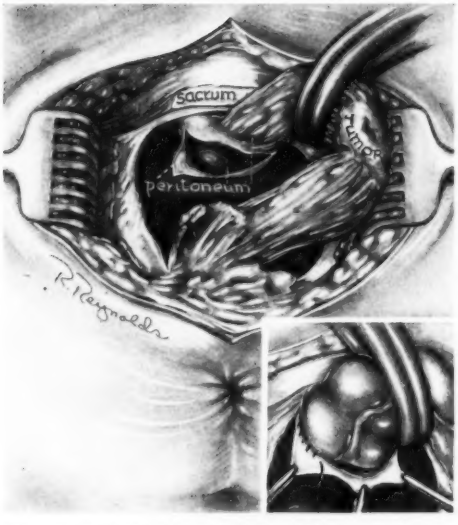

Fig. 10. Posterior dissection followed by a resection and anastomosis. Anastomosis completed as in Figures 8 and 9.

mucosal wall (Fig. 8). Interrupted mattress sutures of silk are inserted around the entire circumference to complete the anastomosis (Fig. 9). By means of an accessory rubber glove, the line of anastomosis is examined from within the rectum. The wound is well irrigated with warm saline solution and sulfanilamide powder is frosted throughout. A Penrose drain is placed in the hollow of the sacrum. The remaining levator muscle tissue and fascia are closed around the rectum with interrupted chromic catgut sutures. These are supported with several heavy silk sutures which also approximate skin and subcutaneous structures. If a supplementary cecostomy was not established, a rubber rectal tube may be inserted up through the line of anastomosis and then fixed to the anal skin. Which is the better method is difficult to say at this time.

PERINEAL DISSECTION WITH PERINEAL RESECTION AND ANASTOMOSIS

The third type of anastomosis for carcinoma of the rectum will be indicated in relatively few cases. One hesitates to say that it is fundamentally sound because one is probably too conservative in removal of the tissue above the lesion, which is in the zone of established spread. However, it may be the operation of choice in some poor risk patient when the entire lesion is palpable per rectum. Also it may be done in selected cases in which the tumor is small, the lower margin of the tumor is at least an inch above the upper margin of the muscular anal canal, and the upper margin can be palpated by the examining finger. The tumor should not be fixed to surrounding structures and should be confined to the mucosa. Murray has recently reported 15 cases in which operation consisted of posterior resection and anastomosis. The tumor area is approached by an incision over the sacrum and coccyx extending to within one-half inch of the anal margin. The coccyx is removed and possibly the fifth sacral body. The tumor is freed as for a posterior excision after the method of Lockhart-Mummery. The peritoneum is opened close to the rectal wall and sufficient sigmoid is delivered to permit excision of the tumor segment and anastomosis of the rectum to the rectal or anal stump (Fig. 10). Anastomosis is accomplished as described in the operation for abdominal dissection with posterior excision and anastomosis (Figs. 8, 9). The wound is liberally flushed with saline and frosted with sulfanilamide. In these cases, cecostomy has been omitted, but a ½ or ⅝ inch tube has been inserted into the anorectal canal to above the line of anastomosis. The perirectal space is drained and tissues closed as previously described. The tube is stitched to the perianal skin. With our limited experience in this type of operation, we are undecided as to the necessity for a supplementary cecostomy. Further experience may prove that it is desirable.

It is our opinion that a nonabsorbable sulfonamide, preferably sulfathaladine, is indicated for 4 to 5 days preoperatively in the preparation of a patient for anastomosis. With open types of anastomosis, some soiling takes place and these drugs may be a safety factor against invasive infection. On several occasions, rather gross soiling has occurred without event. Penicillin has been given postoperatively in 25,000 to 50,000 unit doses every 4 hours, beginning immediately and continued for 5 to 10 days. In several cases where a marked break in technique occurred, surprisingly clean posterior wounds have resulted.

ANALYSIS OF CASES

During a recent 6 month period, I saw 18 patients with carcinoma of the rectum or rectosigmoid. Surgery was advised in all but 3 instances. One of these 3 patients had a rather large tumor fixed to the sacrum and surrounding structures, with urinary incontinence secondary to a previous perineal prostatectomy, and electrocoagulation was selected as the method of treatment. Two other cases were labelled inoperable because of extensive local disease and evidence of distant metastasis. This is an 84 per cent operability rate. Of the 15 patients explored, 13 (72.2 per cent of the 18 cases) were resected. Of the 13 resectable lesions, only 2 were subjected to abdominoperineal excision with permanent abdominal colostomy. In the other 11 patients (84.6 per cent of the resectable lesions), colostomy was avoided by anastomosis of the sigmoid, rectal or anal segments. Of the 11 cases, 8 were done by abdominal resection and anastomosis, 2 by abdominal dissection with posterior resection and anastomosis, and 1 by posterior dissection, resection, and anastomosis. There was one hospital death in a case of abdominal resection and anastomosis in a large, heavy set individual, when probably the result would have been different if a combined abdominoperineal excision had been done. This is a mortality rate of 6.6 per cent for the patients subjected to operation and a mortality rate of 7.6 per cent for patients subjected to resection. This mortality rate in a rather small series of cases in which, where sphincter preservation has been accomplished in 84.6 per cent of the cases, compares quite favorably to the mortality rate in cases in which the avoiding of colostomy is not attempted. However, I believe a higher potential mortality exists as the operation is more difficult, more time consuming, and the incidence of infection is undoubtedly higher where an awkward anastomosis is attempted. Before the advent of the antibiotic agents now available, and the more energetic use of blood plasma and whole blood transfusions, resection and anastomosis of the rectal segments carried a much higher morbidity and mortality rate, and this restricted the enthusiasm for sphincter preservation. In obese and poorer risk patients, abdominoperineal excision or posterior excision without anastomosis would seem to carry less hazard.

CONCLUSIONS

At this time, very few conclusions can be drawn as to the probable end-results over the 5 and 10 year periods in these operations for restoring intestinal continuity after resection of the rectum and rectosigmoid. In general, the sphincter function has been adequate and in most cases remarkably satisfactory. Theoretically, as based on anatomical and pathological dissection, an effort should be made to prove or disprove the expediency of this less destructive operative procedure but only after another 5 years or more, with reports from numerous authors, can the true evaluation be made. In the interval, however, some patients will have had a happier existence for a longer or shorter period because of a retained sphincter mechanism. If the end-results in 5 year cures or ultimate cures do not vary more than 5 to 10 per cent from the results of abdominoperineal excision with permanent colostomy, the operation should be one of choice, or at least patients should be given an opportunity to make the decision. Our present evaluation of the more conservative operation as regards morbidity and mortality is predicated on results obtained when we were unable to exercise the finer details of judgment, technique, preoperative and postoperative care, and control of infection.

REFERENCES

1. ALLINGHAM, W. Diagnosis and Treatment of Diseases of the Rectum. 5th ed. London: J. A. Churchill, 1888.
2. ARNOLD, H. R., and SHEA, J. H. Arch. Surg., 1940, 41: 110–113.
3. BABCOCK, W. W. Surg. Clin. N. America, 1932, 12: 1397.
4. BACON, HARRY E. Surg. Gyn. Obst., 1945, 81: 113–127.
5. BALFOUR, D. C. Ann. Surg., 1910, 51: 239.
6. CADOL, ARMAND. Arch. gen. méd., 1898, 1: 571–605.
7. COLLER, F. A., KAY, E. B., and MCINTYRE, R. S. Surgery, 1940, 8: 294.
8. DEVINE, H. B. Brit. M. J., 1935, 2: 1245.
9. DIXON, C. F. Surgery, 1944, 15: 367.
10. DUNPHY, J. E. Arch. Surg., 1940, 43: 1076.
11. FALLIS, L. S. Surgery, 1943, 14: 307.
12. GABRIEL, W. B., DUKES, C., and BUSSEY, H. J. R. Brit. J. Surg., 1935, 23: 395.
13. GILCHRIST, R. K., and DAVID, V. C. Ann. Surg., 1938, 108: 621.
14. GIRALDES. Quoted by Pennington.

15. GRINNELL, R. S. Ann. Surg., 1942, 116: 200–216.
16. HOCHENEGG, J. Wien. klin. Wschr., 1889, 2: 515.
17. HORSLEY, J. S. Surg. Gyn. Obst., 1937, 64: 313.
18. KOCHER, T. Zbl. Chir., 1874, 1: 145–147.
19. KRASKE, P. Verh. Deut. Ges. Chir., 1885, 14: 464.
20. LISFRANC, J. Rev. méd. fr., 1826, 2: 389.
21. LOCKHART-MUMMERY, J. P. Lancet, Lond., 1908, 1: 1402–1512.
22. MAUNSELL, H. W. Lancet, Lond., 1892, 2: 473.
23. MILES, W. ERNEST. Lancet, Lond., 1908, 2: 1812.
24. MURRAY, GORDON. Surg. Gyn. Obst., 1946, 82: 283–289.
25. PANNETT, C. A. Med. Press & Circ., Lond., 1943, 209: 244.
26. PENNINGTON, J. R. A Treatise on the Diseases and Injuries of the Rectum, Anus and Pelvic Colon. Philadelphia: P. Blakiston's Son and Co., 1923.
27. POIRIER, P., CUNEO, and DELAMERE, G. The Lymphatics. Chicago: Keener & Co., 1904.
28. QUENU, E. Bull. Soc. chir. Paris, 1897, 23: 163–173.
29. RANKIN, F. W. Surg. Gyn. Obst., 1937, 64: 705–710.
30. SHEDE. Deut. med. Wschr., S1048, 1887.
31. TUTTLE, JAMES P. Diseases of the Anus, Rectum and Pelvic Colon. New York: D. Appleton & Co., 1902.
32. VERNEUIL, A. Sem. Med., 1873, 12: 146.
33. WANGENSTEEN, O: H. Surg. Gyn. Obst., 1945, 81: 1–23.
34. WESTHUER, H. Die Pathologish-anatomischen Grundlagen der Chirurgie des Rectum Karzinomas. Leipzig: G. Thieme, 1934.

TISSUE PROTEIN DEPLETION

A Factor in Wound Disruption

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J. WILLIAM HINTON, M.D., New York, New York

WOUND disruption has been reported in 1.5 per cent of abdominal operations (9). This occurrence is associated with a mortality of 35 per cent, and a train of complications such as intestinal obstruction, peritonitis, and incisional hernia. The more common etiological factors are: technical errors, poor suture material, compromise of the nerve and blood supply of the wound, infection, obesity, straining by coughing, vomiting or distention, debilitating systemic disease, vitamin C deficiency (10), and hypoproteinemia (16, 17, 33). This study concerns the relationship between protein depletion and wound disruption.

Clark in 1919 showed that a diet high in protein shortens the lag period in the repair of experimental wounds. Such a diet accelerates the return of the would to maximal tensile strength (11). Utilizing a serial tensile strength method (19), Localio and Hinton (20) have shown that gain in wound strength is markedly delayed in hypoproteinemic rats.

Thompson and associates were the first to implicate protein deficiency as a major factor in postoperative wound disruption. Koster and Shapiro (17) shortly thereafter demonstrated that in cases of human wound dehiscence the mean serum protein concentrations were lowered. Serum protein levels of less than 6.0 grams per cent were noted in 42 per cent of the 40 cases of wound disruptions reported by Koster and Kasman (16).

In reviewing several cases of evisceration which had the benefit of meticulous operative technique, nonabsorbable suture material (cotton), massive doses of vitamins preoperatively, and in which no wound infection occurred, we noted normal plasma protein levels in many of the patients. However, protein deficiency was suspected clinically. This led us to question whether significant depletion of the tissue proteins might occur in the face of essentially normal serum protein levels, and whether the concentration of tissue proteins might in such cases be more directly related to wound healing than the level of the circulating serum proteins. Consequently, the attempt has been made to compare tissue protein concentrations in cases of wound dehiscence with those of normal patients.

In the course of these studies we have been impressed with the need for clarification of the present terminology. For instance, the term "hypoproteinemia" is far too often used as a synonym for protein deficiency in general. Elman (8) states that "the term protein deficiency rather than hypoproteinemia has much to recommend it as a more accurate and useful designation. . . ." In order to provide a simpler terminology, it is proposed that the term "hypoproteinism" be adopted in referring to the depletion of protein from the tissues of the body in general, whether or not serum protein concentrations, as determined by the usual clinical methods, are significantly reduced. "Hypoproteinemia" should be used only to describe a subnormal serum protein concentration.

MATERIAL

The patients were chosen from the Surgical Services of the New York Post-Graduate Hospital, the Fourth Division of Bellevue Hospital, and the Doctors' Hospital, New York.

A control group of 17 individuals was made up of patients who were undergoing laparotomy for benign conditions, and who were considered on the basis of history and physical examination to be in a good state of nutrition.

The second group of 21 consisted of patients suffering from a debilitating disease, and who were therefore suspected of hypoproteinism.

From the Surgical Research Laboratory, New York Post-Graduate Medical School and Hospital, New York.

Because of their preoperative clinical condition, they were also considered to be potential candidates for wound dehiscence. Fourteen had gastrointestinal carcinoma or peptic ulcer.

A third series of 17 patients had experienced postoperative wound disruption.

METHODS

In all cases blood samples were drawn for serum protein determinations either immediately before or after operation. The method used for total protein concentration was modified from Koch and McMeekin. The albumin fraction was isolated according to Howe. Tissue protein concentrations were determined by a technique similar in principle to that used by Elman and Heifetz (7) namely:

Tissue specimens consist of about 2 to 3 square centimeters of fascia, peritoneum, and muscle. The specimens are taken during operation from the rectus muscle and sheaths, superior to the semilunar fold of Douglas. They are carefully dissected free of fat and other adherent tissue, wrapped in gauze slightly dampened with isotonic saline, and rushed to the laboratory. They are weighed immediately to the nearest milligram on an analytical balance. Each specimen is then placed in a 50 cubic centimeter volumetric flask with about 0.5 cubic centimeter of concentrated (100 gm. per 100 c.c.) sodium hydroxide and 8 to 10 cubic centimeters of isotonic saline. The flask is placed in a boiling water bath until the tissue is completely digested (30 to 60 minutes). Upon cooling, saline is added to the 50 cubic centimeter mark. An aliquot consisting of 3.0 cubic centimeters is placed in a Nessler protein tube and the total nitrogen is determined by the same method as for serum protein. The resultant tissue nitrogen concentration is multiplied by 6.25 to give the protein concentration in percentage of wet tissue.

RESULTS

Individual and mean values for the tissue protein concentrations in normals are given in Table I. It is interesting to note that in the 3 cases, in which the peritoneal specimens were taken below the semilunar fold of Douglas without posterior rectus sheath, the protein concentration was rather low.

Table II lists the results in the group of 21 patients who were considered clinically to be in a state of hypoproteinism. All but 6 have normal serum protein levels. The tissue protein concentrations vary considerably. In comparing the fascial protein concentrations of this group with those of the normal patients of Table I, it is seen that no normal patient had a fascial protein concentration of 24.0 per cent or below. If 24.0 per cent is chosen as the lower limit of normal, then 11 of the 21 debilitated patients in Table II demonstrate a diminished fascial protein concentration despite the fact that 5 of these 11 patients had preoperative amino acid therapy. Six had normal serum proteins at the time of operation.

The 17 cases of evisceration (Table III) have significantly lower mean tissue protein concentrations than the patients of the normal control group. This is illustrated in Table IV. The mean fascial protein concentration of the patients who had wound disruptions is also significantly lower than that of the debilitated patients who did not suffer disruption as shown in Table V. Serum protein levels were low in only 4 of the 17 cases of evisceration, even though the determinations were made on blood drawn at the time of evisceration. Unfortunately, serum albumin levels are not available for most of these patients.

DISCUSSION

It is generally agreed that a subnormal serum protein concentration denotes protein deficiency. The converse, however, need not be true. Our results indicate that significant tissue protein depletion may exist in the face of serum protein levels, which by present clinical standards are normal. In this study, using the method of Koch and McMeekin, we have considered 6.0 grams per cent to be the lower limit of normal for total serum protein concentration in agreement with Kagan and Trevorrow.

Riegel and associates state that the "plasma protein concentration may be misleading as an index of whether or not the patient is overcoming excessive nitrogen loss. In some instances, although concentrations (corrected for change in hematocrit) were increased, the patients were in negative nitrogen balance."

TABLE I.—TISSUE PROTEIN CONCENTRATIONS IN NORMAL PATIENTS

Case No.	Age	Diagnosis	Operation	T.S.P. gm.%	Alb. gm.%	Tissue protein concentration per cent of wet tissue			Preop. amigen i.v.	Suture material	Remarks
						Fascia	Peritoneum	Muscle			
1	21	No disease	Exploratory laparotomy	7.5	—	32.1	24.8	17.9	50 gm. o.d. ×7	Cotton	
2	42	Cholelithiasis	Cholecystectomy	7.0	—	25.6	33.8	19.5		Catgut	
3	43	Cholelithiasis	Cholecystectomy	6.1	—	28.5	25.6	20.6	—	Catgut	
4	52	Cholelithiasis	Cholecystectomy	8.0	—	35.9	26.4	11.3	—	Cotton	
5	43	Ut. leiom.	Hysterectomy	7.9	—	35.9	20.0	18.2	—	Cotton	
6	60	No disease	Exploratory laparotomy	8.2	—	27.5	28.1	15.7	100 gm. o.d. ×7	Cotton	
7	22	Ovarian cyst	Ovarian cystectomy	7.0	—	29.1	24.7	19.6		Cotton	
8	41	Cholelithiasis	Cholecystectomy	7.1	—	24.3	19.9	22.1	—	Cotton	
9	21	Ischiorectal abscess	Exploratory laparotomy	6.9	—	30.9	26.2	23.6	—	Cotton	
10	51	Sigmoid diverticulitis, mild	Exploratory laparotomy	7.2	3.8	22.9	14.0*	22.2	—	Cotton	
11	33	Retroversion of uterus	Uterine suspension	6.5	3.7	27.6	9.2*	17.9	—	Catgut	
12	40	Healed appendiceal abscess	Interval appendectomy	7.7	3.1	24.4	19.0	17.9	—	Cotton	
13	41	Pelvic inflam. abscess	Panhysterectomy	6.0	3.7	32.2	20.6	23.4	—	Catgut	
14	41	Appendiceal abscess	Incision, drainage	6.9	3.7	27.2	7.4*	19.4	—	Cotton	
15	41	Cholelithiasis	Cholecystectomy	6.9	4.6	27.4	22.2	16.9	—	Cotton	
16	47	Ovarian cyst	Ovarian cystectomy	8.9	4.9	30.3	22.3	20.7	—	Cotton	
17	49	Acute appendicitis	Appendectomy	7.1	4.7	30.7	27.0	17.2	—	Cotton	
		Mean tissue protein concentration					29.0	24.29	19.35		
		Standard deviation					± 3.67	± 3.99	± 2.26		

*Peritoneum taken below semilunar fold of Douglas and therefore omitted from consideration.

There are many reasons why the serum protein level may be misleading as an index of the state of protein nutition: Reduction in the total circulating serum albumin is often accompanied by considerable decline in plasma volume, thus tending to maintain a normal serum protein concentration (18, 22, 24, 25, 28). Meyer and Kozoll attempt to detect this hemoconcentration by serial determinations of the hematocrit. Unfortunately, however, some of the most crucial surgical patients suffer from various degrees of anemia simultaneously with hypoproteinism, thus tending to nullify the hemoconcentration effect.

Determination of the serum protein level without evaluating the albumin fraction frequently will fail to disclose a hypoalbuminemia, which is masked by the presence of hyperglobulinemia secondary to chronic infection (13, 25) and other stimuli. Thus, in some instances, a state of hypoproteinism may be detected by albumin determinations but not by the total serum protein concentration. Unfortunately, the accuracy of the albumin determination, as routinely performed in many laboratories, leaves much to be desired.

If it is true that the total serum protein concentration is not a reliable index of hypoproteinism, the question then arises as to whether accurate determination of the albumin fraction will solve this problem. Elman and his co-workers (6, 8, 31) in this regard have emphasized the work of Weech who noted a prompt hypoalbuminemia in dogs on a protein-free carrot diet. That this is not necessarily applicable to human patients can be seen from the fact that in young men placed on a semistarvation diet with a protein con-

TABLE II.—TISSUE PROTEIN CONCENTRATIONS IN DEBILITATED PATIENTS

Case No.	Age	Diagnosis	Operation	T.S.P. gm.%	Alb. gm.%	Tissue protein concentration per cent of wet tissue			Preop. amigen i.v.	Suture material	Remarks
						Fascia	Peritoneum	Muscle			
1	56	Cirrhosis of liver, jaundice	Exploratory laparotomy	6.1	—	28.9	22.2	18.6	100 gm. o.d. ×6	Cotton	
2	27	Regional enteritis	Resect. of ileum and right colon	6.8	—	25.2	25.6	23.1	100 gm. o.d. ×10	Cotton	
3	62	Metastatic ca. of liver	Exploratory laparotomy	6.6	—	30.3	25.7	15.6	—	Cotton	
4	53	Ca. of colon	Resection of colon	6.3	—	26.3	31.3	13.3	50 gm. o.d. ×5	Cotton	
5	51	Gastric ulcer	Gastrectomy, subtotal	7.6	—	21.1	25.3	18.1	—	Catgut	
6	64	Carcinomatosis peritonei	Exploratory laparotomy	5.4	—	19.3	17.6	15.4	50 gm. o.d. ×4	Cotton	Peripheral edema P. O. #12
7	79	Ac. cholecystitis senility	Cholecystectomy	5.5	—	22.6	29.2	17.6	—	Cotton	
8	37	Duodenal ulcer	Subtotal, gastrectomy	4.8	—	34.4	30.1	15.6	—	Cotton	
9	60	Ca. of sigmoid	Resection of sigmoid	8.5	—	26.5	27.8	19.1	100 gm. o.d. ×5	Cotton	
10	70	Gen. art'scl.	Exploratory laparotomy	5.9	—	23.6	14.8	13.4	100 gm. o.d. ×7	Cotton	
11	62	Intest. obst. 16 da. postgastrec	Lysis of adhesions	7.9	—	24.9	16.8	17.8	—	Cotton	
12	56	Ca'sis peritonei	Exploratory laparotomy	6.2	3.0	22.0	22.0	6.1	—	Cotton	
13	63	Ca. of sigmoid	Resection of sigmoid	5.5	2.2	22.3	22.7	15.4	—	Cotton	
14	46	Cholelithiasis with jaundice	Choledochostomy cholecystectomy	6.1	2.5	24.5	20.4	17.2	—	Cotton	
15	40	Duodenal ulcer	Subtotal gastrectomy	6.1	3.0	22.0	26.4	17.4	100 gm. o.d. ×3	Cotton	
16	22	Duodenal ulcer	Subtotal gastrectomy	6.1	4.5	29.0	20.9	19.9	50 gm. o.d. ×5	Cotton	
17	53	Ca. of sigmoid	Resection of sigmoid	6.7	3.2	25.8	19.9	18.0	—	Catgut	
18	60	Duodenal ulcer	Subtotal gastrectomy	7.0	3.2	16.0	22.2	19.6	100 gm. o.d. ×4	Cotton	
19	72	Ac. cholecystitis senility	Cholecystectomy	5.3	—	20.1	18.9	12.5	—	Cotton	
20	54	Ca. stomach with metas.	Resection of stomach and jejunum	6.8	3.0	22.8	24.3	15.0	100 gm. o.d. ×7	Cotton	
21	60	Ca. colon	Resection of colon	6.9	2.9	23.6	21.8	20.2	—	Cotton	
			Mean tissue protein concentration			24.38	22.86	17.05			
			Standard deviation			3.99	±4.77	±2.55			

tent of only 49 grams a day for a 6 month period, "the plasma protein fell only slightly and the A/g ratio remained within normal limits" (14). This was despite the fact that these 34 men lost an average of 24.5 per cent of their body weight and all developed significant edema. Other recent studies (5) have confirmed the finding of normal serum albumin and total protein concentrations in the presence of "famine edema." No clear explanation of this phenomenon was offered. Thus, even the serum albumin level is not a consistent index of hypoproteinism.

Ravdin predicted that ". . . if the means to determine it were available, the first effect of protein undernutrition is a reduction in the amount of protein stored in the tissues of the body since every attempt is made to maintain the serum protein concentration at a nearly normal level." However, it has never previously been demonstrated by direct measurement that depletion of tissue protein actually does occur in humans in the presence of normal serum protein concentration. Our results demonstrate that depletion of the fascial protein may be revealed by the method described, at a time when the serum protein concentration is within normal limits. The muscle nitrogen concentration is not as sensitive an indicator of early hypoproteinism. One factor

TABLE III.—TISSUE PROTEIN CONCENTRATIONS IN CASES OF WOUND DISRUPTION

Case No.	Age	Diagnosis	Operation	T.S.P. gm.%	Alb. gm.%	Tissue protein concentration per cent of wet tissue			Preop. amigen i.v.	Suture material	Remarks
						Fascia	Peritoneum	Muscle			
1	56	Carcinoma of stomach	Gastrectomy	4.9	—	13.1	13.4	14.5	Preop. 50×7 Postop. 50×7	Cotton	Evisceration p.o. 7
2	57	Uterine leiomyomas ovarian cyst	Hysterectomy oophorectomy	7.3	—	19.0	14.1	13.7	—	Catgut	Evisceration p.o. 7 severe cough p.o. 6–7
3	62	Perforated peptic ulcer	Suture of perforation	7.9	—	20.2	19.9	14.8	—	Catgut	Evisceration p.o. 8
4	56	Perforated peptic ulcer	Suture of perforation	6.2	—	17.7	26.2	16.8	—	Catgut	Evisceration p.o. 7 bronchopneum p.o. 2
5	56	Uterine leiomyomas	Hysterectomy	5.5	—	11.2	14.3	—	—	Catgut	Evisceration p.o. 6 TSP-7.4 gm. % on date of operation
6	67	Carcinoma of rectum	Abdominoperineal resection	5.0	—	19.0	17.4	18.9	—	Cotton	Evisceration p.o. 8
7	38	Perforated peptic ulcer	Closure of perforation	5.0	—	17.5	19.6	18.9	—	Catgut	Evisceration p.o. 8
8	65	Ca. of sigmoid	Anterior resection	6.2	—	19.8	21.1	21.9	Preop. 100×6 Postop. 100×5	Cotton	Evisceration p.o. 10 wound infection p. o. 6
9	46	Intestinal obstr.	Lysis of adhesions	9.6	—	21.9	24.3	22.0	—	Cotton	Evisceration p.o. 8
10	44	Ca.'tosis peritonei	Colostomy	6.3	—	20.4	17.7	16.7	—	Cotton	Evisceration p.o. 9 died p.o. 19
11	56	Duodenal ulcer	Gastrectomy	7.3	—	20.5	22.2	11.9	Preop. 100×5 Postop. 100×5	Cotton	Evisceration p.o. 7 sev. cough p.o. 3–7
12	59	Ca.'tosis peritonei	Exploratory lap.	6.1	— —	17.9 17.3	24.5 20.3	13.9 15.6	— —	Cotton	Evisceration p.o. 2 2nd evis. p.o. 11
13	51	Ca. of sigmoid	Resection of sigmoid	7.4	2.1	26.0	23.1	23.0	100 gm. o.d.×6	Cotton	Evisceration p.o. 12
14	37	Duodenal ulcer	Subtotal gastrectomy	7.1	2.9	20.3	16.3	8.7	Preop., × post op. 100 gm. o.d. × 7	Cotton	Evisceration p.o. 7 severe cough
15	63	Bleed. duod. ulcer	Subtotal gastrectomy	6.4	2.5	17.5	25.3	17.8	4 l. blood	Cotton	Died p.o. 7 of uremia with disrup. of fascia and peritoneum
16	67	Perf. of stomach, traumatic	Suture of perforation	6.7	3.7	22.7	—	17.6	—	Cotton	Evisceration p.o. 7
17	45	Gastric ulcer	Subtotal gastrectomy	7.2	3.9	14.4	18.4	15.4	Preop. 100×5 Postop. 100×4	Cotton	Evisceration p.o. 10
			Mean tissue protein concentration			18.73	19.77	16.82			
			Standard deviation			±3.31	±2.35	±3.53			

may be the rapidity with which muscle loses moisture. It has been noted that a 250 milligram sample of wet muscle may lose as much as 2.0 milligrams per minute during weighing; thus is introduced a serious technical error.

In view of the acknowledged importance of the fascial layer in wound healing, it is of interest that the lowest tissue protein values were encountered in the fascia of patients with wound disruptions, indicating that severe hypoproteinism frequently occurs in these cases despite apparently normal serum protein levels. It is therefore considered that the degree of protein depletion of the fascia is more directly related to failure of wound healing than is the degree of serum protein depletion, as measured by total protein concentrations.

Outstanding among the recent advances in the field of protein metabolism is the concept of "dynamic equilibrium" which governs the

TABLE IV.—COMPARISON OF MEAN TISSUE PROTEIN CONCENTRATIONS IN CASES OF WOUND DISRUPTION AND IN NORMAL PATIENTS

	Normal patients per cent	Wound disruptions per cent	Difference per cent	Statistical significance*
Mean protein concentration of fascia	29.00	18.73	10.27	t=8.36 n=33 P less than .01 Therefore significant
Standard deviation	3.67	3.31	1.18**	
Mean protein concentration of peritoneum	24.29	19.77	4.52	t=3.78 n=29 P less than .01 Therefore significant
Standard deviation	3.99	2.35	1.21**	
Mean protein concentration of muscle	19.35	16.82	2.53	t=2.41 n=32 P .024 Therefore probably significant
Standard deviation	2.26	3.53	1.02**	

*The statistical significance of the difference between the two groups was tested by the t-test as described by Fisher, R.A., in *Statistical Methods for Research Workers*, 7th ed., Edinburgh, Oliver and Boyd, 1938.

**The standard deviation of the differences between the respective means was calculated by the formula

$$\text{S. D. Diff.} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$$

where σ_1 and σ_2 are the standard deviations of the normal and the disruption groups respectively, and N_1 and N_2 are the number of cases in each group respectively.

TABLE V.—COMPARISON OF TISSUE PROTEIN CONCENTRATIONS IN CASES OF WOUND DISRUPTION AND IN DEBILITATED PATIENTS

	Debilitated patients per cent	Wound Disruptions per cent	Difference per cent	Statistical significance
Mean protein concentration of fascia	24.38	18.73	5.65	t=4.60 n=37 P less than .01 Therefore significant
Standard deviation	3.99	3.31	1.17	
Mean protein concentration of peritoneum	22.86	19.77	3.09	t=2.38 n=36 P .025 Therefore probably significant
Standard deviation	4.77	2.35	1.19	
Mean protein concentration of muscle	17.05	16.82	0.23	Not significant
Standard deviation	2.55	3.53	1.02	

interchange of proteins between the blood and tissues (32). Following rapid plasma protein depletion by plasmaphoresis, a normal dog may re-form as much as 40 to 60 per cent of its total circulating plasma proteins even during fast (23). Whipple and his co-workers (23) showed that the source of the regenerated serum proteins were "reserve stores" of protein metabolites existing in various tissues. The nature and location of the tissues reserves have posed a difficult problem. It has been suggested by Addis (1, 2), that the liver has a large fraction of labile protein which may be utilized by the organism during fast. The composition of this "reserve" protein is apparently identical with the total protein of the liver cells (21). That the dynamic equilibrium between serum and tissue proteins operates in the reverse direction may easily be illustrated by maintaining animals in positive nitrogen balance for indefinite periods of time on protein-free diets supplemented only with intravenous injections of plasma (37). In a healthy organism, of course, it is expected that the tissue cells are capable of participating in the dynamic equilibrium of protein metabolism and of extracting from the total pool of body protein the metabolites necessary for their specific functions. It may be, however, that this equilibrium is disturbed in the diseased state. This suggests another possible explanation for the disparity between the protein concentration of the tissues and the serum, as noted in Table III.

One may account for the disparity between the determined protein concentrations of the tissues and the serum in several ways: The serum protein concentration may not reflect a reduction in total circulating proteins because of a contracted plasma volume. The total serum protein level may be normal in the face of hypoalbuminemia. Normal total serum protein and albumin levels have been shown to occur in severe hypoproteinism and even in "nutritional" edema (14, 30). The body may attempt to maintain homeostasis of the serum protein concentration at the expense of tissue proteins (29). In diseased states there may be breakdown or delay of the "dynamic equilibrium" between serum and tissue proteins.

By way of practical application, our findings serve to emphasize the study of the patient as a whole rather than of his serum protein concentration. The extensive literature on "hypoproteinemia" in surgery has focused considerable attention upon the results of the serum protein determination alone. Unfortunately, too often a normal serum protein level has been interpreted to be an adequate

index of the preoperative patient's protein nutrition. Needless to say, a normal serum protein concentration often affords a sense of security that is entirely false, and the surgeon may underestimate badly the quantity of protein necessary properly to prepare his patient for major surgery. Calculation of the probable protein needs of the preoperative and postoperative patient should be based upon the nature and duration of the lesion, the dietary history, loss of weight and clinical appearance, and not solely upon the result of a serum protein determination. Cases of gastrointestinal carcinoma (3) and peptic ulcer (27), for example, should receive intensive preoperative protein therapy. This is especially true because in cases involving gastric or intestinal anastomoses, failure of wound healing at the site of anastomosis is tantamount to catastrophe. Varco has recently provided a practical guide to the methods of protein therapy.

Since our data are at present incomplete with regard to the relationship between tissue proteins and the serum albumin fraction, studies in this direction are now being pursued and will be reported later. Preliminary findings indicate that under certain conditions, hypoproteinism may occur even with normal or borderline albumin concentrations.

SUMMARY AND CONCLUSIONS

1. The level of tissue proteins was determined in fascia, peritoneum, and muscle in normal humans.

2. Estimation of the protein concentration of the fascia is offered as a means of ascertaining the state of protein nutrition.

3. Depletion of the protein of the fascia seems to be an important factor in the etiology of wound disruption.

4. The total serum protein may be maintained within normal limits even in the face of significant depletion of the tissue protein. Hence, in humans, the serum protein concentration does not constitute an adequate index of the state of protein nutrition.

5. The term hypoproteinism is proposed to describe the state of depletion of tissue protein, whether or not this is accompanied by simultaneous depletion of serum protein.

REFERENCES

1. ADDIS, T., POO, L. J., and LEW, W. J. Biol. Chem., 1936, 115: 111.
2. Ibid., 117.
3. ARIEL, I. M., ABELS, J. C., PACK, G. T., and RHOADS, C. P. Surg. Gyn. Obst., 1943, 77: 16.
4. CLARK, A. H. Bull. Johns Hopkins Hosp., 1919, 30: 117.
5. Editorial. N. England J. M., 1946, 235: 32.
6. ELMAN, R. Parental Alimentation in Surgery. New York: Paul B. Hoeber, 1947.
7. ELMAN, R., and HEIFETZ, C. J. J. Exp. M., 1941, 73: 417.
8. ELMAN, R., and LISCHER, C. Surg. Gyn. Obst. (Internat. Abstr. Surg.), 1943, 76: 503.
9. HARTZELL, J. B., and WINFIELD, J. M. Surg. Gyn. Obst. (Internat. Abstr. Surg.), 1939, 68: 585.
10. HARTZELL, J. B., WINFIELD, J. M., and IRVIN, J. L. J. Am. M. Ass., 1941, 116: 669.
11. HARVEY, S. C., and HOWES, E. L. Ann. Surg., 1930, 91: 641.
12. HOWE, P. E. J. Biol. Chem., 1921, 49: 93.
13. KAGAN, B. M. South. M. J., 1943, 36: 234.
14. KEYS, A., TAYLOR, H. L., MICKELSEN, O., and HENSCHEL, A. Science, 1946, 103: 669.
15. KOCH, F. C., and MCMEEKIN, T. L. J. Am. Chem. Soc., 1924, 46: 2066.
16. KOSTER, H., and KASMAN, L. P. Arch. Surg., 1942, 45: 776.
17. KOSTER, H., and SHAPIRO, A. Arch. Surg., 1940, 41: 723.
18. LEPORE, M. J. Proc. Soc. Exp. Biol., N.Y., 1932–1933, 30: 268.
19. LOCALIO, S. A., CASALE, W., and HINTON, J. W. Surg. Gyn. Obst., 1943, 77: 243.
20. LOCALIO, S. A., and HINTON, J. W. Unpublished data.
21. LUCK, J. M. Liver Proteins, in Needham, J. and Green, D. E. Perspectives in Biochemistry. New York: Macmillan Co., 1937.
22. LYONS, R. H., JACOBSON, S. D., and NEERKIN, J. L. J. Lab. Clin. M., 1945, 30: 404.
23. MADDEN, S. C., and WHIPPLE, G. H. Physiol. Rev., 1940, 20: 194.
24. METCOFF, J., FAVOUR, C. B., and STARE, F. J. J. Clin. Invest., 1945, 24: 82.
25. METCOFF, J., and STARE, F. J. N. England J. M., 1947, 236: 26.
26. MEYER, K. A., and KOZOLL, D. D. Surg. Gyn. Obst. 1944, 78: 181.
27. MULHOLLAND, J. H., CO TUI, WRIGHT, A. M., and VINCI, V. J. Ann. Surg., 1943, 117: 512.
28. PETERS, J. P. J. Mt. Sinai Hosp., 1942–1943, 9: 127.
29. RAVDIN, I. S. Surg. Clin. N. America, 1946, 26: 1306.
30. RIEGEL, C., KOOP, C. E., DREW, J., STEVENS, L. W., and RHOADS, J. E. J. Clin. Invest., 1947, 26: 18.
31. SACHAR, L. A., HORVITZ, A., and ELMAN, R. J. Exp. M., 1942, 75: 453.
32. SCHOENHEIMER, R. The Dynamic State of Body Constituents. Cambridge: Harvard University Press, 1946.
33. THOMPSON, W. D., RAVDIN, I. S., and FRANK, I. L. Arch. Surg., 1938, 36: 500.
34. TREVORROW, V., KASER, M., PATTERSON, J. J., and HILL, R. M. J. Lab. Clin. M., 1941–1942, 27: 471.
35. VARCO, R. L. Surg. Gyn. Obst., 1947, 84: 611.
36. WEECH, A. A. Harvey Lect., 1938–1939, p. 57.
37. WHIPPLE, G. H., and MADDEN, S. C. Medicine, 1944, 23: 215.

EDITORIALS

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VAGOTOMY

ALTHOUGH numerous debatable issues remain regarding the exact place that vagotomy should assume in the treatment of peptic ulcer, since Dragstedt and his associates focused attention on this procedure in 1943, certain aspects of the subject have become defined with a fair degree of clarity. It therefore seems appropriate that some comment be made at this time regarding what has been learned and the deficiencies in our knowledge which still exist. Many of the physiologic effects of bilateral section of the vagus nerves in man have been repeatedly demonstrated and verified. It is of more than passing interest that these observations coincide closely with those made previously in the experimental laboratory. Thus, it is known that after vagotomy the neurogenic stimulation of gastric secretion is removed, the amount of nocturnal gastric secretion is reduced, emotion fails to alter the gastric mucosa, hypoglycemia does not stimulate the secretion of gastric acid, and gastric hypomotility results. Other less significant effects also have been noted. Vagotomy does not eliminate sensory stimuli from the stomach or duodenum.

The influence of vagotomy on the accessory organs of digestion has been incompletely investigated from a physiologic point of view. To date, no serious deleterious effect on the function of these structures has become apparent. Certain symptoms, such as diarrhea and abdominal cramps which occasionally occur after vagotomy, have not been satisfactorily explained. Likewise, our knowledge is incomplete concerning the physiologic effects of vagotomy on the small intestine and large bowel. A most important question which has not been answered definitely as yet is how long the effects of vagotomy persist. Certain experimental evidence (Vanzant) as well as some clinical evidence presented by Moore suggests that the effects of vagotomy may be temporary. Results of other clinical studies do not substantiate this point of view. Clarification of this important point will require further time. Various methods of dealing with the cut ends of the vagus nerves have been devised and tried in order to obviate possible regeneration and restoration of vagal continuity. Physiologic studies made several years or more after vagotomy to determine the status of vagal function should state clearly what method was employed to secure the ends of the vagus nerves.

Granted that vagotomy still is in the phase of clinical trial and that at present complete unanimity of opinion does not exist regarding the indications for this procedure, a certain amount of agreement in respect to certain points seems to prevail among those most in-

terested in the subject. Thus, Grimson, Colp, and many others agree that thoracic vagotomy alone should not be employed as a routine operation for the treatment of duodenal ulcer. This is largely because of failure of the stomach to empty properly in a significant percentage of cases in which the thoracic approach has been used. This failure may occur even despite lack of evidence preoperatively to suggest pyloric obstruction. In addition, this procedure affords no opportunity for verification of the lesion at the time of operation, which in itself is not an inconsequential consideration.

In contrast, most all agree that vagotomy alone constitutes a most welcome contribution to the treatment of jejunal ulcer which occurs after gastric resection. In fact, it is thought by many that this lesion constitutes the most definite indication for vagotomy today. Opinion is less well formulated on the use of vagotomy alone in the management of jejunal ulcer which follows gastroenterostomy, for under these circumstances the second phase of gastric secretion remains active.

At present, most discussion revolves around abdominal vagotomy associated with gastroenterostomy as the operation of choice for duodenal ulcer. According to Dragstedt, this is a most satisfactory operation; however, Walters and others have reported somewhat less brilliant results. A final decision on this subject will require the lapse of more time. At the time when end-results are reported, evidence also should be presented regarding the percentage of cases in which the postoperative findings suggested either complete or incomplete section of all vagal fibers. I have found it more difficult to feel confident that all vagal fibers were sectioned when an abdominal, rather than thoracic, approach is used. Not all surgeons share this opinion. The abdominal approach affords the obvious advantages of permitting direct inspection of the lesion and the abdomen in general, in addition to an opportunity to perform any associated surgical procedure that is indicated. Theoretically, the operation which should afford the greatest chance to cure duodenal ulcer and prevent subsequent jejunal ulcer is vagotomy associated with high resection of the stomach. It seems possible that in a small group of selected cases this operation may have a certain field of usefulness.

Most surgeons agree that in the treatment of gastric ulcer, vagotomy should seldom be used because of the excellent results which follow properly performed gastric resection and the possiblity of failure to remove an actual carcinoma. Vagotomy might be considered in the small group of gastric ulcers which by all evidence appear to be benign and which are situated in such proximity to the esophagus that extirpation of the lesion would require total gastrectomy. The number of such cases is extremely small, for in the large majority of high-lying gastric ulcers subtotal gastric resection with removal of the ulcer or local excision and gastroenterostomy can be performed. In exceptional cases of this type, subtotal gastric resection without removal of the ulcer may be considered if the ulcer has all the appearance of benignity.

JAMES T. PRIESTLEY

THE NURSE ANESTHETIST

THE purpose of this editorial is to consider the case of the nurse anesthetist and to examine some of the factors that will influence the man without bias who must consider the matter.

The controversy. Whether or not the nurse anesthetist is a valuable adjunct to the care of the patient has been a matter for discussion for a good many years. Many well known professors of surgery are in sharp disagreement

with the majority of physician anesthetists on this question.

The controversy has been pointed up by the recent action of the American Society of Anesthesiologists, Inc. This organization has circularized hospitals with a copy of a resolution adopted by its Board of Directors, June 11, 1947. As far as the present discussion goes, the most important part of this resolution is the disapproval expressed "Of the training of persons other than doctors of medicine in the science and art of anesthesia . . . .," in short, nurses.

Quoting further from the notice sent to hospitals, "This resolution has been reproduced and commented upon in the *Journal of the American Medical Association* and many State and County medical journals. In none of these has it been criticized adversely." Nevertheless, the concept contained in the resolution has, as everybody knows, been criticized strongly both in and out of print. For example, as recently as January 11, 1947, Dr. Evarts Graham[1] said: "There are some prominent anesthesiologists who would eliminate completely the nurse anesthetist. They have even supported legislation in some states which would make it illegal for a surgeon to engage the services of a nurse anesthetist. . . . The best solution to the problem then is to encourage the training of the nurse anesthetist until there are enough physician anesthesiologists to fill the demand." We may take it that there has been widespread criticism of the *policy* advocated by the resolution. The policy is under discussion.

Some weak points of hospitals in utilizing nurse anesthetists. There have been a good many instances of abuse of the earning power of nurse anesthetists by hospitals. The exploitation of one department of a hospital to support the institution must be condemned. It is wrong in principle. There is nothing in this which says that the anesthesia department should not contribute its fair share to payment of the hospital's overhead, bookkeeping, heat, light, janitor service, etc. If the hospital buildings have been given to the institution, no rental should be charged. The well run department of anesthesia should also retain, after all of its own expenses are paid, a reasonable percentage of its earnings for further development of the department. If the department makes money beyond these charges, its fees should be lowered for the patient's sake.

The training of nurses by nurses without real medical supervision is another fair target for the anesthesia society to shoot at.

The above are problems of administration; on the professional side is the fact that the clinical limitations of the nurse anesthetist are sometimes not adequately perceived.

The nurse anesthetist unquestionably has her limitations. In the writer's opinion, her peace-time activities should in most cases be limited to the administration of ether anesthesia and nitrous oxide-oxygen. It has been said that if she is allowed to give ether she might as well administer pentothal sodium, cyclopropane, spinal anesthesia, etc. This statement is not sound for the simple reason that ether has the greatest factor of safety of any of the commonly used major agents. When the respiration fails from overdosage of ether the intake stops spontaneously *before* circulatory damage has occurred. This does not appear to be true with other agents. The hazards of the nurse administering agents other than ether are sufficiently great so that she should be limited, except in unusual circumstances, to this agent and nitrous oxide. She still can be extremely useful.

Some vulnerable points in the argument offered by anesthesia groups. War was a great accelerator of development of the specialty

[1] Graham, E.A. J.Am.M.Ass., 1947, 133: 97-100.

of anesthesia. Many surgeons in military service got better anesthesia than they had previously ever had. With this and other stimuli aiding the specialty, the tendency is to pull it in the desirable direction faster than it can go. The great limiting factor here is the present shortage of trained physician anesthetists. Of all the specialists in medicine, the anesthetist seems to be scarcest. He has the greatest scarcity value. It sometimes seems as though every one of the 7000 hospitals in the United States is trying to get a physician head for its anesthesia department. This is a fine tribute to the physician anesthetist and the place he has made for himself. It is by no means to be construed as a total rejection of the nurse anesthetist.

At present, well known anesthesia training centers have waiting lists of reassuring size. This is not the case over the country as a whole. Many large as well as small hospitals are already feeling the shortage of physicians for training in anesthesia.

Great numbers of physicians recently discharged from the military services have been eager for training in anesthesia; but this pressure is now much less than it was. In another couple of years men released from the A.S.T.P. and V-12 programs will no longer be available. At the same time the expansion of government facilities, as well as the civilian demand over the country is increasing. For these and other reasons it seems probable that the shortage of good men for training in anesthesia will be increasingly acute for at least several years.

Any unnecessary pressure that adds to the critical nature of this situation will win the ill will of many physicians, especially surgeons who ought to be solidly behind the anesthetist. The resolution referred to can work to the harm of the specialty, and in addition by giving rise to strong opposition defeat its own ends.

With the rapid development of physician anesthesia and with the great shortage of trained personnel, it is curious that the resolution referred to should be offered at this time. It of course immediately raises the question of who at present will assume the load now carried by the nurse anesthetist, if the resolution is widely accepted. The local doctor on the case? In this period of critical shortage of trained personnel, to outlaw the nurse anesthetist would inevitably mean that in great numbers of cases the surgeon would be forced to use the local doctor on the case as his anesthetist. The inadequacies of this system do not need comment. The situation is hardly solved by the attitude, "We'll use 'em, but we won't train 'em."

While large medical centers can often carry out their anesthesia responsibilities largely with a very low salaried resident staff and can keep the cost actually lower than it would be if nurses were used, this raises several problems beyond the scope of the present discussion. Even though this may be the case in the large medical centers, in the outlying hospitals where the bulk of surgery is done, abolition of the nurse anesthetist requires the employment of a physician anesthetist or the use of inadequately trained staff members. Aside from the fact that the physician anesthetist is in most cases at present unobtainable by the outlying hospital, it must be recognized that, if he could be obtained, the cost of medical care will thus be increased, such increase to be embarked upon only with greatest caution.

The old-line, large hospitals are fairly generally running large deficits. A recent editorial in the New York *Times* (September 30) calls attention to the fact that hospital deficits in the New York area are about two and one-half times in 1946 what they were in 1945. It is unlikely that the average smaller hospital in the country is better off. With the costs of

all things rising to critical levels and medical care not the least of these, it seems surprising that the resolution referred to should be pressed at this time.

If the resolution is offered with the mental reservation that it will not be emphasized until some time in the future, it still works a present effect in deterring nurses, already critically few from going into anesthesia.

Dangerous principles. The censorship of medical practices by society action (in so far as they lend to inflexible regimentation) may have a bad long range effect upon the society when applied to widespread general practices in the care of the patient.

The use of a certifying board for coercive action, by threats to remove certification in order to alter widely accepted general practice may be questioned.

There is much talk of legalistic means to force and inevitably freeze, the shape of medical practice. The hazards of this have been demonstrated. Recourse to law by a medical society in order to correct what it believes to be unsound professional practices will freeze the undesirable along with the desirable. In case the law freezes inadequately tested procedures, it will be difficult to make later needed adjustments. Surely every thoughtful physician must look with deepest reluctance on moves by the medical profession to take to the law to shape its practice. Physicians need to guide their own affairs.

The future. The nurse anesthetist is needed now; what her future position will be, the writer does not know.

Let us not try the impossible. We cannot at present fill the available positions for physician anesthetists; therefore, of what use are impatient attempts to hasten an evolutionary process that is already proceeding faster than we can take advantage of it?

Unquestionably, a well trained physician anesthetist should head the department of anesthesia, with as many physician associates as the needs of his institution require. It seems inescapable that with current shortages in this field, continued training of the nurse anesthetist is at present indicated.

HENRY K. BEECHER.

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THE BOOK SHELF

THE CANCER OF DESTINY

ESTHER H. VINCENT, Evanston, Illinois

NAPOLEON was dropped from the womb of time on sun-baked Corsica, a bare rock-mass of an island, its thorns and water torrents, its dark ribbons of pines thrusting themselves ambitiously up out of the Mediterranean blue. Spoil of many a war, Corsica had scowled under Ligurian, Carthaginian, Roman, Vandal, Papal, Moorish, and Genoese masters before finding itself a bit of French real estate. Its fishing villages and mountain hamlets still stand like gray heaps of stone, silently indifferent to the burning suns and scorching winds of adversity. Its fishermen and goatherders, its fruit and chestnut growers, are a short-statured, grave folk, filled with dreams of grandeur based on an innate sense of equality with the great of the earth. Theirs, too, is a curious, heightened sensibility to the thoughts of others, an uncanny susceptibility to the shadows of future events. Theirs is a deep love of solitude, from which they derive a feeling of security, of courage and fidelity. Like all primitive people they are as vain as children, and they are clannish to the point of absurdity, favoring relatives regardless of personal worth and efficiency.

NAPOLEON BONAPARTE
1769–1821

The Bonaparte family was of noble Tuscan ancestry, but had dwelt in Corsica since the 16th century. Probably little Italian influence was left by the time young Napoleon appeared, although the family name was spelled Buonaparte for many a year. Father Charles Bonaparte had married a young girl of the island, Letizia Ramolino, by whom he had 13 children, 8 of whom lived. Tall and vigorously beautiful, Napoleon's mother was said by him to have had the mind of a man. She shared the stormy life of the Corsican rebels under Paoli, and many a tale is told of her sagacity and fearlessness. Once, while crossing a turbulent river, her horse lost its footing and was being carried downstream. Letizia, ignoring the shouted advice to jump, successfully guided the frightened animal to safety. She was then carrying Napoleon in her womb. Married at 15, Letizia lived through the dramatic rise and fall of her famous child, even staying with him at Elba, and finally ending her days peacefully at Rome at the age of 86.

It was from his mother that Napoleon liked to think he had inherited those qualities that made him great. But it was from his father that he feared he had inherited the physical constitution that would destroy him. Lawyer Charles Bonaparte fought with Paoli for the liberation of Corsica. Upon the defeat of the leader, he retreated with his family to the mountains, only to come down again to take up the life of a parasitical

From the Archibald Church Library, Northwestern University Medical School.

collaborator, fawning upon the French governors in an effort to secure social prestige and free schooling for his offspring. From this little respected parent, Napoleon inherited not only a delicate oval face and blue-gray eyes, but also a predisposition to gastric cancer. Grandfather Joseph Bonaparte had died at 40 of that disease, and Father Charles, aged 39, duly showed up at autopsy with a scirrhous carcinoma of the greater curvature of the stomach. During his last days at Montpellier, where he had gone with the hope of cure, Charles seemed to have a curious insight into the future, raving about the greatness of his son, who would change the face of the earth. At this time Napoleon was a poor little cadet in military school.

All his life Napoleon lived with the fear of cancer. He did not want to talk about it, and he never mentioned his father's illness if he could avoid it, but every now and then he would disclose a queer interest in anatomy, particularly in the anatomy of the stomach. However, every time he tried to learn something about it, he got sick at it. Physically squeamish, he simply could not stand the sight of the parts of a dead body. When he was Emperor, he took a few private lessons from his court physician, Corvisart, but the only result was a pale, nervous, depressed Napoleon, whose wife, Marie Louise, wondered why he could not eat his dinner.

Whenever conversation turned upon digestion, Napoleon always vehemently asserted that he had an excellent stomach. In reality he frequently had gastric pain, and even in early youth, was subject to nausea and vomiting. Sometimes he would say:

"When disease appears in the stomach, a physician's experience is expended in vain, for it is the restorative center itself which is affected. The stomach is the most important part of the body."

When his last physician, the inefficient Antommarchi, suggested that the exiled emperor's stomach might be diseased, Napoleon told him to stop his nonsense, that the Napoleonic stomach was perfectly sound! Yet, a month before his death, with the true nature of his illness still unknown, he suddenly began to ask another of his attendants, Dr. Arnott, about the anatomy and physiology of the stomach. And in dying, he repeated in delirium, "The pylorus . . . My father . . . The pylorus . . ." And finally, consciously, "I have known it . . . for a long time."

This fixed idea that he would die from cancer of the stomach saved him from fear of death in any other form. Wounded in battle, he took no heed, for he knew he would not die from bullets. His belief in his charmed life in combat was not fearlessness or bravery, nor faith in his "miraculous invulnerability," but certainty that death could touch him in one way only. Upon realizing the imminence of defeat at Waterloo, he deliberately put himself in the way of bullet streams, hoping to defy fate, but to no avail.

Along with his furtive interest in gastric anatomy went an almost despairing concern in the heredity of disease. Four of his brothers and sisters, Lucien, Elisa, Pauline, and Carolina, all suffered from stomach afflictions (eventually all 4 died of cancer or of suspected cancer). Almost pitifully he would ask his physicians for assurance as to the impossibility of disease inheritance. He firmly believed in it, but wanted terribly not to!

According to Dr. Paul Gosset, "The Bonapartes were a dynasty as much arthritic as imperial." Such "slowed-down nutrition" people are frequently victims of tense agitation, spenders of reserve, with a predisposition to serious disease. Generally impatient, they gulp their food, accelerate living in general, and thus promote nutritional strikes.

The schoolboy Napoleon was short and thin. Lacking good muscular co-ordination, he could not throw stones with efficiency, nor ride horses without falling off of them. Too awkward to inveigle his hair into the elaborate male coiffure of the day, he resorted to professional hairdressers, and got the habit of carrying his three-cornered hat under his arm in order not to muss his hair. His "nervous stomach" reflected his every emotion, and vomiting followed mental upsets. Never could he digest milk, nor even foods prepared with milk. His great eyes stared out of his sickly face, and his voice was harshly hollow. But his living habits were simple, even Spartan, and he knew how to make use of such energy as he had, just as he knew how to make use of his fellow students.

A thin, bedraggled, girl-like soldier of the Revolution, he earned the title of "Little Corporal" through his magical ability to spread the contagion of courage among the men with whom he ate his coarse black bread and with whom he slept on the straw-strewn ground under the cannon. Threatened with amputation of his bayoneted leg, he ignored surgeon Hernandez, and, without rest, returned to the fray that won Toulon for his army.

As a young lieutenant at Auxonne, he presented himself as a thin, yellow creature, bedridden for many weeks with what was probably the malarial fever still endemic to that region. He bombarded Bienvelot, the regimental surgeon, with questions as to the nature of his illness, and 6 months later his health was still wobbly from the infection.

At Antibes in Château-Sallé he had a serious digestive disturbance, which was treated by a Dr.

Desgenettes, who prescribed so long a list of ineffectual remedies that he nearly undermined Napoleon's faith in the medical profession, and, at the same time, nearly killed him with oratory. At this time, Napoleon looked like a vagabond, with his clumsy, uncertain gait, shabby clothes, and emaciated body. Stendhal states that the Napoleon of this period was the thinnest and most peculiar looking individual he had ever seen.

After the execution of Robespierre, the ensuing crisis in the Revolutionary Convention led to the appointment of Napoleon as commander in chief of the army. The feverish activities consequent upon this first step to power did not improve his health. Josephine was dismayed at his sickly looks. After their marriage, he continued to have colds and racking coughs and chest pains. Corvisart diagnosed the trouble as pulmonary congestion, although he refrained from alarming Napoleon by telling him so. It is highly probable that Napoleon was suffering from an active pulmonary tuberculosis, spontaneous recovery occurring later, when, at the close of his consulship, life grew easier for him. Corvisart's treatment of the acute attack was successful, however, and Napoleon was so pleased with the distinguished doctor that he made him his personal physician, showering him with honors.

Napoleon's talent for judging personal worth served him well in his choice of medical men. The great Larrey was his chief military surgeon, and Corvisart was not only his first physician, but also his very good friend. In 1803, Corvisart had a national reputation as clinician and teacher. Among his many brilliant pupils was Laennec, father of the stethoscope. Corvisart revived Auenbrugger's art of percussion, and, though he did not have auscultation, he was a good diagnostician. At the time of his first meeting with Napoleon, Josephine asked the physician what he thought her husband would die of. Corvisart made a snap diagnosis of heart disease. Future clinical examinations and the autopsy showed nothing abnormal with the imperial heart. It had an even, though slow beat, and never gave him any anxiety. But Corvisart's guess interested him, led to a discussion of aneurisms and heart disease in general, and resulted in Corvisart's writing a book on the subject and dedicating it to Napoleon. Thus there came into being one of the first books on clinical cardiology, Corvisart's *Essai sur les maladies et les lesions organiques du coeur et des gros vaisseaux* (1806).

Napoleon was quick to spy out a charlatan, but had the highest regard for an honest physician. Corvisart attended both Josephine and Marie Louise in their many imaginary ills, and supported the latter's somewhat psychopathic pregnancy by dosing her with bread pills to her immense satisfaction. Corvisart stood by Napoleon even after the debacle of 1814, and it was only his own ill health (apoplexy) that kept him away from St. Helena.

Science, particularly medical science, fascinated Napoleon. Although hostile to mere speculation, he enthused over practical research. He was so pleased with Jenner's vaccine discovery that he initiated French experiments on smallpox, and authorized a decree ordering national vaccination. One of the first French children to be vaccinated was his own little son.

The Emperor was a difficult patient, however, believing in "natural self-regulation" and saying that he preferred to die from disease than from medicine. His physicians were forced to resort to hygienic measures alone. He was peculiarly sensitive to cold, kept a fire in his room even in summer, and daily boiled himself in hot baths, further stimulating his sluggish circulation by strenuous massage. Horseback riding also increased his bodily heat. He slept but a few hours at a time, could sleep and waken at will on a campaign, but would waken quickly to a strange noise or odor at home. In later life, pestered by dysuria, he changed beds frequently during the night. He often fasted, but, when he did eat, he ate too much and too rapidly. As time went on, he experienced severe gastric pain after meals, and sometimes nausea and vomiting.

Contemplating pictures of Napoleon in characteristic pose, right hand stuck in his waistcoat and left hand thrust behind his back, and aware of the prevalence of scabies in the France of the Revolution, many people have thought that he was always scratching himself. Whether Napoleon had the itch, or whether Napoleon did not have the itch, is a moot point. Stories concerning it seem chiefly legendary, however. He is said to have become infected with some kind of skin ailment at Toulon, after he had replaced a slain cannoneer at his gun. This scabby affair, known as *la gale*, was very prevalent among the soldiers, and it tormented Bonaparte for years. As popular verse, it broke out thus:

"Un jour, Napoléon, me prenant par la main,
Cette faveur est sans égale,
Dit: 'De moi vous aurez quelque chose demain.'
Le lendemain, j'avais la gale."

At this period scabies was regarded as a constitutional disease. To cure it was fatal, for, if driven from the skin, it might turn up in the vital organs, and, contrariwise, an infected skin might draw

disease from the organs. Thus, Napoleon in Egypt is said to have been exposed to the itch in order to cure his gastric pain. Whatever he had, whether scabies or dermatitis herpetiformis or what you will, its symptoms abated under the care of Corvisart, and appeared only at intervals thereafter as a chronic pruritus, turning into what Antommarchi termed "neurotic excoriations" at St. Helena.

During the years of struggle for world power, Napoleon grew increasingly nervous and irritable. His temper, stable enough in important matters, disintegrated into paroxysms of anger over trivial frustrations. He raged at the courtier who made an inept witticism, and at the valet who made a clumsy gesture. He developed a series of tics—spasmodic shrugs of the right shoulder, mouth twitchings from left to right, tremors of the left calf. At St. Helena, the mere presence of the abhorrent Governor Lowe would set Napoleon's leg to trembling. Along with tics and nervousness went a mania for destruction. He stabbed his chair arm with a penknife, ripped his clothing, and smashed the china. He cried easily over trifles. An emotional tempest would occasionally bring on a nervous fit, and he would seem to lose consciousness and fall to the floor. Lombroso thought him a psychotic epileptic, with his insolent egocentricity and his lack of moral sense. Kovalevsky, the Russian psychiatrist, also considered him epileptic, as did the Spaniard, Juarros. Nevertheless, many of the characteristic symptoms of epilepsy were absent, and his physicians never mentioned epilepsy in their records, nor even in their personal correspondence.

When about 40 years old, Napoleon began to gain weight and to acquire almost female contours. From sickly yellow, his complexion changed to a marbly white. From dynamic seriousness, his expression changed to dull ennui. His speech became halting and hesitant; his public addresses cold and monotonous. Even his features seemed to change. He was often tired and sleepy, suggestive of a kind of narcolepsy. This slow decline of his powers affected the turn of history. Ségur attributes the failure of the Russian campaign to Napoleon's passivity. Two days before Borodino (September, 1812) Dr. Mestivier reported that he had a continuous dry cough, difficult respiration, scant and painful urination, edematous legs, and feverish pulse. Although Napoleon soon improved in health, there is no doubt but that his ailments interfered with his efficiency. At Dresden he was seized with so violent a gastric pain that he made the faulty decision that cost him the battle. Pain and weariness were with him at Leipzig (October, 1813), the battle which decided the fate of the Empire. Melancholy and apprehension followed him to Paris, where in April, 1814, he signed his abdication.

His flight from Elba coincided with a sudden outburst of activity, but his "march" to Paris was that of a tired, listless man riding in a carriage. His grave somnolency was at least partly responsible for his defeat at Waterloo (June, 1815).

The jagged, gloomy rock called St. Helena is 600 miles from the nearest land, and Longwood, the seat of Napoleon's exile, is at the summit of the island's most remote mountain, cold, damp, windy, shadeless, and waterless. The governor, Sir Hudson Lowe, a wretched bully of a man, was haunted by the idea that Napoleon was trying to escape. Aggravated by his prisoner's evident antipathy, he half killed him with petty annoyances. The mortality rate of the island was very high, most of its inhabitants dying from liver complaints. Lack of fresh vegetables added scurvy to Napoleon's other troubles. His hitherto perfect teeth began to ache and to decay.

The British physician, Dr. Barry O'Meara, was banished by Governor Lowe in 1818, partly because the doctor showed sympathy with Napoleon, and partly because he diagnosed his illness as hepatitis, the disease for which the island was notorious. With O'Meara's departure, Napoleon was freed from an endless round of calomel and purgatives. He was without medical attendance for some months, refusing to see any medical man sent him by the governor. But in January, 1819, he became so ill that a visiting ship's doctor, John Stokoe, attended him without governmental authority, and was court-martialed as a result.

Through the efforts of the Bonaparte family, Dr. Francesco Antommarchi, a young Corsican, educated at Pisa, and professor of anatomy at Florence, was sent to care for Napoleon in September, 1819. Antommarchi, influenced by Governor Lowe, regarded his patient's illness as imaginary, laughed at his agony, and put tartar emetic in his lemonade. Whenever Napoleon needed him, Antommarchi usually had to be summoned from Jamestown, 3½ miles away. An experienced physician would have recognized the presence of serious gastric pathology, but Antommarchi merely aggravated Napoleon's sufferings by pouring drugs into him. At last, Dr. Archibald Arnott, surgeon of the 20th Regiment, was called, and had the good sense to see that the disease lay, not in the liver, but in the stomach. By this time (April, 1821) Napoleon was having gastric hemorrhages and his heart action was very weak. Antommarchi's remedy was to apply a vesicatory to the

epigastric region. On the 4th of May, a day of tropical storm, Napoleon was in complete collapse, and at 6 o'clock the following morning, he was dead.

Twenty and a half hours after death, Dr. Antommarchi held the autopsy in the presence of Dr. Arnott and 6 other army surgeons. Strangely enough, the body was fairly fat, the heart and omenta being adipose. The abdomen was distended, the peritoneum being covered with viscous fluid. On the anterior surface of the stomach at the lesser curvature near the pylorus there was found a complete perforation, now closed with adhesions. The internal surface of the stomach was practically covered by a cancerous mass, as were all of the adjacent lymph nodes. The liver and spleen were engorged and there were many adhesions between the liver and stomach. The urinary bladder contained small calculi. The left kidney was slightly displaced and congenitally (?) enlarged. Antommarchi thought he saw signs of tuberculosis in the left lung, but Arnott thought the lungs normal. The brain was not dissected.

Napoleon's body had many female characteristics—small hands and feet, smooth, practically hairless skin, wide hips, and narrow shoulders. The genitalia were small and atrophied, possibly due to some pituitary lesion.

Cause of death was undeniably cancer of the stomach. The state of the bladder suggested the cause of his frequency of micturition and dysuria. Fragments of an ileum, purporting to be that of Napoleon, are preserved in the Museum of the Royal College of Surgeons. These specimens show evidence of Malta fever, which Napoleon could conceivably have contracted while on Elba. It is known that he had feverish attacks on St. Helena. However, the origin of the fragments is very doubtful.

At first buried in a simple, unmarked grave on his island prison, in 1840 the body of Napoleon was triumphantly returned to France. And once again, that strange Napoleonic power, springing from the energy of a dynamic though never healthy man, roused to ecstasy the Parisian crowd, which with one mighty voice proclaimed, "*Vive l'Empereur!*"

REFERENCES

1. Bechet, P. E. Jean Nicholas Corvisart, physician to the Emperor Napoleon. Ann. M. Hist., 1940, 2: 401.
2. Idem. Napoleon—his last illness and post-mortem. Bull. N. York Acad. M., 1928, 4: 469.
3. Friedman, Reuben. The Emperor's itch. Bull. Hist. Med., 1940, 8: 949.
4. Halls Dally, J. F. Jean Nicolas Corvisart (1755-1821). Med. Rec., 1941, 153: 233.
5. MacLaurin, Charles. Post mortem. P. 208. New York: G. H. Doran Co., 1922.
6. Sokoloff, Boris. Napoleon; a Doctor's Biography. New York: Prentice-Hall, Inc., 1937.
7. Tarbell, I. M. A Short Life of Napoleon Bonaparte. New York: The S. S. McClure Co., 1896.

REVIEWS OF NEW BOOKS

WRITTEN from the combined experiences of a clinical neurologist, a neuropathologist, and a psychiatrist, *Neurosyphilis* by Merritt, Adams, and Solomon[1] approaches the subject from the total standpoint. The emphasis on the progressive pathological picture, e.g. the relationship of the meningeal reactions seen early in the disease to the late picture of tabes dorsalis, general paresis, or diffuse meningovascular involvement is well placed. This relationship is unfortunately slighted in many books which describe categories as static lesions with the result that the importance of early preventive treatment of the more curable phase of the illness is missed.

The book is well documented, first with a rich clinical material available to the authors in two large American cities, and second with a generous review of the literature. Many of the illustrations are related to old therapies, e.g. Swift-Ellis now outmoded, but the lessons are clear.

The general practitioner, not too conversant with neurological and psychiatric thinking may object to the detail of neuropathology, neurophysiology, psychopathology, and psychiatric serology, but such criticisms are easily answered. The neuropsychiatrist will enjoy the detailed descriptions of the meningeal lesions, the vascular lesions and the varying clinical picture. The relative incidence of these lesions is shown clearly, and differences between simulating lesions like multiple sclerosis and cerebral arteriosclerosis emphasized in the case histories. The combination of syphilis with other neurological disease, e.g. brain tumor, is pointed out so that valuable weeks and months will not be lost in misdirected treatment.

The limitations of therapy in neurosyphilis may be appreciated in the clinical illustrations. Too often the medical student is taught that syphilis is treated by "specific" drugs and hence is curable. He projects this concept into neurosyphilis, forgetting that the scar of tabes or the organized thrombus in the middle cerebral artery leave irreversible defects in the neural mechanism. This book corrects such thinking but emphasizes the reversible lesions, the early meningeal involvements, the mild vascular syndromes and, of course, the parenchymatous lesions of general paresis. Since many of the case illustrations are old, fever therapy does not receive the prominent place it now holds. Similarly in the light of the developments of the past 2 years, the chapter on penicillin is pitifully small and the information meager. Already a second edition is called for as the data, previously confidential for security reasons, become available for publication.

The book has the not unusual sins of a first edition, errors in grammar, but these are trivia, easily corrected in a second edition.

The book, however, is a real addition and is recommended for the library of every neurologist, psychiatrist, syphilologist, and the general practitioner who encounters sizable numbers of these patients in his practice. BENJAMIN BOSHES.

[1]NEUROSYPHILIS. By H. Houston Merritt, A.B., M.A. Hon., M.D., Raymond D. Adams, M.A., M.D., and Harry C. Solomon, B.S., M.D. New York: Oxford University Press, 1946.

HOWEVER complete, *Penicillin in Syphilis* by Moore[2] is intended only as a supplement to an earlier and larger volume, *The Modern Treatment of Syphilis* by the same author, now in the third printing, of the second edition. A book on penicillin in syphilis had to be written and it is well that this was done by a thorough student and a mature writer. The errors of a first edition enthusiast, both scientific and rhetorical, are thus avoided. Penicillin is a potent therapeutic aid, a useful one, a substance which has already established itself in the medical and public eye. It has its uses and its limitations, and as one becomes more conversant with this antibiotic, it has its dangers too. A tremendous literature on penicillin in syphilis had accumulated because the need was great for a safer, less time-consuming, and more economical drug than bismuth or arsenic.

To collate this literature, to sift it down to what was definite, carefully controlled, statistically significant, required a person who was thoroughly familiar with syphilis as a disease and with penicillin as a therapeutic agent. It was fortunate, therefore, that Dr. Moore elected to write this book as a supplement to his textbook on *The Modern Treatment of Syphilis*. The author recognizes that many of the facts in the book are dated, that tables of dosages are being tested and revised daily, that more complete evaluations of penicillin G, X, K, etc. and of even the so-called "impurities" are already appearing. However, someone must prepare a baseline and the reviewer appreciates the historical features, the experimental data, and the basic pharmacological facts which appear in the first 8 chapters. These are the pillars on which the use of a drug is built and it was essential to document them. To prepare this rich literature, collected and critically reviewed in one volume is a real contribution. Some may object to wading through this mass of material, but not the research worker or the alert clinician, be he specialist or not. Some of the chapters on therapy are long; others are short. These are not sins of omission, but merely the author's principle of adhering to facts.

[2]PENICILLIN IN SYPHILIS. By Joseph Earle Moore, M.D. Springfield, Ill.: Charles C Thomas, 1946.

Penicillin is a drug which is being tested continuously in certain designated, qualified places, as well as by individual research men. The validity of data is related to available material. It will take a long time to collect a statistically significant series of Erb's syphilitic spinal spastic paraplegia. There are simply too few cases; therefore, such a chapter is brief as yet.

The style of the book is easy and friendly. Despite numerous tables, graphs, and discussions of data, the pages can be read rapidly. There is an amazing freedom from gross grammatical errors for a first edition. This reviewer found only one slip, page 259 where the author lists the pupillary changes, the fifth, third, and second cranial nerve involvements of tabes dorsalis as "cerebral." The word "cerebrum" could well be left out of paragraph 4. The legibility of the book is enhanced by a large clear type appearing on nonreflecting pages. Details stand out clearly in bold-faced type.

Penicillin in Syphilis is recommended to everyone who is interested in the antibotic as such, or in the modern treatment of this ubiquitous disease.

BENJAMIN BOSHES.

THREE new chapters have been added in the second edition of *Human Gastric Function* by Stewart Wolf and Harold G. Wolff[1] published 4 years ago. The work extends that of Dr. Beaumont on Alexis St. Martin and of Dr. Carlson on Mr. V., and is primarily a report on the gastric functions of "Tom" as they were affected by drugs, by mechanical stimuli, and especially by emotion. "Tom" at 9 years developed an esophageal stricture after drinking extremely hot clam chowder, and submitted to a gastrostomy. These studies were carried on when Tom was in his fifties, and the investigators used ingenious and skillful techniques in their work.

They observed that after liquids had been introduced into the stomach there was a temporary inhibition of gastric contractions. Fluids introduced directly into the duodenum resulted in more prompt inhibition of gastric contractions, but the duration of effect was the same. Many believe that this effect of fluids accounts for the relief that ulcer patients obtain when milk and alkalies are administered. Wolf and Wolff found that introduction of acid inhibited contractions. Palmer, however, has shown that introduction of acid accentuates ulcer pain. Possibly the inhibitory action of fluids may be lost when ulcer or inflammation of the mucous membrane is present.

Mucin content they believe important, for occasionally when acid values have been very high mucin content has been low. This has occurred "during periods of serious dilemma in Tom's life." They observed that alcohol effected an increase in "vascularity, secretion, and motor activity." Smoking caused no significant change. As for a large group of chemical agents used, many were able to influence motor activity, vascularity, and acid secretion, though the effect varied in accordance with "the subject's prevailing emotional state at the time or with his affective reaction to the experimental procedure itself."

"Profound alterations" in gastric functions as well as in other bodily patterns were found to accompany emotional disturbances. There was depression of function if the patient withdrew "from an emotionally charged situation," and acceleration of function if he assumed an aggressive attitude. This influence of the emotions emphasizes again the importance of the mental outlook of a patient with ulcer and the necessity of teaching him to change his reactions to the problems of living.

There is one study of a patient with peptic ulcer before and after vagotomy. The results are valuable because of the present interest in bilateral vagotomy. Apparently the vagi are "not essential to the gastric hyperemia that follows the ingestion of a meal."

Everyone interested in physiology and gastroenterology is indebted to Tom and to the authors for this scientific study and well written book.

ARTHUR J. ATKINSON.

IN trying to include all of the diseases of the locomotor system as well as rheumatic fever in one volume Dr. Fletcher has undertaken a Herculean task. In *Medical Disorders of the Locomotor System Including the Rheumatic Diseases*[2] he has an excellent approach, which is to classify everything on an etiologic basis and also to take into consideration the physiologic aspect as well as the changes in anatomy. He realizes that these pioneer efforts are attended with difficult problems which will have to be solved in the future. He has deliberately given much prominence to the rheumatic diseases since he recognizes that they are a social scourge and a national problem the world over. He has devoted long chapters to the anatomy and physiology of the locomotor system, but he recognizes the lack of complete and reliable information on the physiologic side. He has obtained help from 10 contributors on different subjects. This has the advantage of making the discussions of all of these subjects authoratitive and based on experience, with the disadvantage that the complete unity of the book has been interrupted.

One of the best things about the book is that it is up to date and at the same time the author passes judgment on new ideas of other authors. He has a critical opinion of the ideas that have recently been advanced by some authors. He bases his opinion on the anatomy and physiology and in general he is quite sound.

The book has a thorough discussion of rheumatoid arthritis and its relation to rheumatic fever. Osteoarthritis is discussed in general, and also for specific

[1]HUMAN GASTRIC FUNCTION; AN EXPERIMENTAL STUDY OF A MAN AND HIS STOMACH. By Stewart Wolf, M.D., and Harold G. Wolff, M.D. 2d ed. London, New York, Toronto: Oxford University Press, 1947.

[2]MEDICAL DISORDERS OF THE LOCOMOTOR SYSTEM INCLUDING THE RHEUMATIC DISEASES. By Ernest Fletcher, M.A., M.D. (Cantab.), M.R.C.P. Baltimore: The Williams & Wilkins Co., 1947.

joints. Specific arthritides and gout are taken up. There is a chapter on sciatica and one on low back pain. The various causes of low back pain are given and the author has some insight into the disturbance in function that causes low back pain. The relationship of the decompensation in function to the anatomic changes is not clear. Poor posture is still thought of as a cause of the back disturbance, rather than as a symptom of decompensation. There is no distinction between the cases in which the decompensation is caused by the anatomic changes and those cases in which the anatomic changes are the result of a decompensation. He has a chapter on the foot which brings out nothing new. In addition, methods of treatment are discussed, particularly with regard to physical therapy and various types of injections.

It is interesting to see a medical point of view brought to a subject that ordinarily comes under the field of orthopedic surgery, and the approach is of value not only to the medical man but also to the orthopedic surgeon and to all who have to do with disturbances in locomotor function, particularly of the rheumatoid type. EMIL D. W. HAUSER.

THE monograph *Les thyroidectomisés* by R. Leibovici and Gilbert-Dreyfus[1] forms a part of a series entitled *L'avenir des opérés* and is evidently intended as a refresher course in the diagnosis, management, and complications of the hyperthyroid state. It suffers the handicap of having been written on the eve of the admission of the thiouracil compounds among the agents acceptable in the treatment of hyperthyroidism, which circumstance substantially reduces its value. Aside from this limitation, the treatise proves to be an orderly and detailed account of a classical medical entity and a careful analysis of the complications of the disease and of its treatment. The point of view is international enough and we have references to American, English, and German authors, although no formal bibliography is included. In the main, there is little disagreement between the French and American principles of diagnosis or of treatment. We all concede that careful evaluation is desirable and that "adequate thyroidectomy" is the therapeutic ideal. It is, rather, in the management of the residual and the recurrent hyperthyroidism that the French surgeons appear willing to enter upon a variety of therapeutic subterfuges, such as the use of protracted lugolization and of irradiation, which would receive scant approval here. It is at this point in the treatise that analysis and definition cease to illuminate and tend to become a trifle specious. EDITH B. FARNSWORTH.

THE ambiguity of the title *Chirurgie fonctionnelle gynécologique*[2] by R. Bourg is lavishly explained in the foreword and introduction as indicative of the author's desire to do surgery and conserve function. The proposition is fair enough, but the conservation of function would seem too obvious a therapeutic ideal to merit such enthusiastic development.

The book consists of an outline developed to meticulous redundancy, under which is described in breezy fashion everything which the gynecological surgeon could possibly do, good and bad, current and obsolete. It is a fabulous bag of tricks.

EDITH B. FARNSWORTH.

THE monograph *Osteotomy of the Long Bones* by Henry Milch[3] is based upon an interesting attempt to explain the failure and success of various osteotomies on a mathematical basis. New descriptive terms are introduced for well established procedures. Impressive laboratory procedures are the polariscopic examination of plastic models under stress, the geometric study of actual bones, and the manipulation of models. Some of the diagrams are simple and will aid the reader in understanding the basic mechanical principles involved in osteotomies. Some are abstract and will tend to confuse him. Mathematicians will be interested in formulas and equations involving higher mathematics; the philosophers in statements such as: "While it is true that a straight line represents the shortest distance between two fixed points, it is equally true that for any fixed length, a straight line represents the longest distance between two points." If a surgeon needs a geometric excuse for cutting off a painful, protruding spike of bone he is given one.

The author's previous contributions are well presented, some of them in revised form. The book is a convenient record of these. The practical analysis of the various types of osteotomies is of value. The varied applications of the high femoral osteotomy, though not new, may be so presented as to increase their utility.

The monograph "shoots over the heads" of most surgeons and will touch lightly only a few of those who have specialized in orthopedics.

WALTER P. BLOUNT.

THE 19th edition of May's *Manual of Diseases of the Eye*[4] contains 387 illustrations including 32 plates with color figures. It is still a concise, practical, and systematic manual intended for the student and general practitioner.

The death of the author, Charles H. May, in 1943 deprived American medicine of a great teacher. The present edition has been revised by Dr. Perera and he is to be congratulated for adhering to the original plan of the book, editing rather than rewriting it.

This edition has been brought up to date by including considerable new material, and several color plates and drawings have been added. The new topics included are penicillin therapy, modern theory of color vision and its anomalies, thyrotropic and

[1] LES THYROIDECTOMISÉS. By R. Leibovici and Gilbert-Dreyfus. Paris: G. Doin & Cie, 1946.

[2] CHIRURGIE FONCTIONNELLE GYNÉCOLOGIQUE. By R. Bourg. Paris: Masson & Cie; Liege: Editions Desoer, 1947.

[3] OSTEOTOMY OF THE LONG BONES. By Henry Milch, M.D. Springfield, Ill.: Charles C Thomas, 1947.

[4] MAY'S MANUAL OF DISEASES OF THE EYE. 19th ed. Edited by Charles A. Perera, M.D. Baltimore: Williams & Wilkins Co. 1947.

thyrotoxic exophthalmos, congenital cataract following maternal rubella and ocular brucellosis. Ocular requirements for admission to the Army, Navy, Marine Corps, Coast Guard, and Aviation services of the United States are contained within the appendix.

May's *Manual* is one of the best textbooks on ophthalmology. It is hoped that future editions will continue to reflect the character and personality of the author.

IRVING PUNTENNEY.

THE fascinating and important field of the relationships of hormones to tumors is outlined in the symposium, *Endocrinology of Neoplastic Diseases* edited by Gray H. Twombly and George T. Pack[1]. The effect of hormones particularly the steroids in initiating and in augmenting or retarding neoplasia as well as the hormonal pictures produced by functioning tumors of the endocrine glands or by carcinomatous destruction of these glands are depicted in detail. Most of the topics discussed are still in the experimental stage and the authors have taken care to present the results of many investigators as completely as possible, to evaluate this work briefly and then only to draw the most thoroughly substantiated conclusions. The defects in our knowledge are pointed out and the need of further research stressed. Such listings of results can make slow and difficult reading, yet in this volume the reader is aided by the consistency and quality of the style of the different authors and by the thoughtful use of subheadings and frequent summaries. The data are timely, in some cases supplements having been added so that the latest work might be included.

Of particular interest to the clinician are the chapters on the endocrine effects of pituitary tumors by William German and on adrenal cortical tumors by Allan T. Kenyon in which the symptoms are tabulated and the mechanism for the production of each symptom postulated, a rationale thus being given to the diagnosis of the unique syndromes these tumors may produce. Tumor endocrinology becomes important therapeutically in cancer of the prostate. This condition is described in detail and contrasted with the different problem presented by benign prostatic hypertrophy. The recent attempts at hormonal treatment of breast cancer are evaluated well by Ira T. Nathanson. The surgeon will be interested in the discussion of parathyroid enlargements by Oliver Cope, and of pancreatic tumors by Allen O. Whipple. Attention is also given to tumors of the ovaries, the testes, the thyroid, and of the pineal in this remarkably complete symposium.

These monographs will be of value to the practitioner to whom the diagnosis of hormone producing tumors is always a challenging problem, to the surgeon in whose province the treatment of most of these conditions lies, and to those interested in research in both endocrinology and cancer who will appreciate such a careful summary of investigations to date.

CHARLES HUGGINS.

[1] ENDOCRINOLOGY OF NEOPLASTIC DISEASES. A Symposium by Eighteen Authors. Edited by G. H. Twombly, M.D., and George T. Pack, M.D. New York: Oxford University Press, 1947.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A PRIMER OF CARDIOLOGY. By George E. Burch, M.D., F.A.C.P., and Paul Reaser, M.D. Philadelphia: Lea & Febiger, 1947.

UNIPOLAR LEAD ELECTROCARDIOGRAPHY; INCLUDING STANDARD LEADS, UNIPOLAR EXTREMITY LEADS AND MULTIPLE UNIPOLAR PRECORDIAL LEADS. By Emanual Goldberger, B.S., M.D. Philadelphia: Lea & Febiger, 1947.

400 YEARS OF A DOCTOR'S LIFE. Collected and Arranged by George Rosen, M.D., and Beate Caspari-Rosen, M.D. New York: Henry Schuman, 1947.

PRINCIPLES OF OCCUPATIONAL THERAPY. Edited by Helen S. Willard, B.A., O.T.R., and Clare S. Spackman, B.S., M.S. in Ed., O.T.R. Philadelphia, London, Montreal: J. B. Lippincott Co., 1947.

HISTORY OF MEDICINE; A CORRELATIVE TEXT, ARRANGED ACCORDING TO SUBJECTS. By Cecilia C. Mettler, A.B., Ed.B., A.M., Ph.D. Edited by Fred A. Mettler, A.M., M.D., Ph.D. Philadelphia: The Blakiston Co., 1947.

BLOOD DERIVATIVES AND SUBSTITUTES; PREPARATION, STORAGE, ADMINISTRATION AND CLINICAL RESULTS INCLUDING A DISCUSSION OF SHOCK; ETIOLOGY, PHYSIOLOGY, PATHOLOGY AND MANAGEMENT. By Charles Stanley White, M.D., Sc.D., and Jacob Joseph Weinstein, B.S., M.D. Baltimore: The Williams & Wilkins Co., 1947.

THE FOOT AND ANKLE; THEIR INJURIES, DEFORMITIES AND DISABILITIES. 3rd ed. By Philip Lewin, M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1947.

SURGICAL DISORDERS OF THE CHEST; DIAGNOSIS AND TREATMENT. By J. K. Donaldson, B.S., M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1947.

HODGKIN'S DISEASE AND ALLIED DISORDERS. By Henry Jackson, Jr., A.B., M.D., and Frederic Parker, Jr., A.B., M.D., New York: Oxford University Press, 1947.

DISEASES OF THE NOSE, THROAT AND EAR. By William Lincoln Ballenger, M.D., F.A.C.S., and Howard Charles Ballenger, M.D., F.A.C.S. Assisted by John Jacob Ballenger, B.S., M.D. Philadelphia: Lea & Febiger, 1947.

CORRESPONDENCE

ABUSE OF THE TERM "SUBTOTAL GASTRECTOMY"

GASTRIC resection for duodenal ulcer has gradually replaced gastroenterostomy which used to be the operation of choice for this condition up to about 20 years ago. In gastric resection for duodenal ulcer about two thirds of the stomach should be removed. In Europe this operation is defined simply as resection of the stomach. In this country the term "partial gastrectomy" was employed for many years and still is used by many leading clinics.[1] Partial gastrectomy is the proper term for this type of operation. For some unknown reason many clinics in this country have adopted the wrong term "subtotal gastrectomy" for this procedure. The unjustifiable misuse of the term, "subtotal gastrectomy," has reached such wide proportions that it seems proper to call a halt to its further abuse in connection with gastric resection for duodenal ulcer.

The term, "subtotal," implies that practically the whole organ is removed and that only a tiny rest of this organ is left behind. Thus in a properly executed subtotal thyroidectomy a minute remnant of this organ remains *in situ*.

[1]Proc. Mayo Clin., 1947, 22:337.

An operation analogous to this type of thyroidectomy is performed when gastric resection for a large gastric ulcer occupying most of the stomach is undertaken. After the removal of such a large gastric ulcer the stomach represents a small pouch composed mainly of part of the fundus.

These extensive gastric resections for large gastric ulcers luckily represent a very small percentage among the operative procedures on the stomach. They have one great disadvantage in their postoperative picture, namely, the annoyance which the small remaining stomach gives to the patient, at least during the first 6 months after the operation. Thus subtotal gastrectomy should be performed only as an operation of necessity in the presence of large gastric ulcers.

Gastric resections for duodenal ulcers which usually comprise about two-thirds of the stomach, should therefore never be classified as subtotal gastrectomies. They should be called partial gastrectomies. If every surgeon, before classifying the gastric operation performed for a duodenal ulcer would remember the picture of a subtotal thyroidectomy, the unjustifiable use of the term, "subtotal gastrectomy," for gastric resections for duodenal ulcers would soon be abandoned completely.

RICHARD LEWISOHN.

VOLUME 86 FEBRUARY, 1948 NUMBER 2

CONTENTS

The Use of Isotopes in Surgical Research. *Francis D. Moore, M.D., F.A.C.S., Boston, Massachusetts* 129

The Rectogenital Septum. *Eduard Uhlenhuth, Ph.D., Walter M. Wolfe, M.D., E. Milton Smith, M.D., and Edmund B. Middleton, Baltimore, Maryland* 148

The Effect of Surgical Interruption of the Gastric Blood Flow upon Gastric Secretion and the Prevention of Experimental Peptic Ulcers. *Harry H. LeVeen, M.D., M.S., New York, New York* 164

The Repair of Hernia; with Special Application of the Principles Evolved by Bassini, McArthur, and McVay. *Carl O. Rice, M.D., F.A.C.S., and J. H. Strickler, M.D., Minneapolis, Minnesota* 169

Redundant Blind Segments of Intestine Following Side-to-Side Anastomosis with Division of the Bowel; Report of 5 Cases. *B. Marden Black, M.D., and Cecil G. McEachern, M.D., Rochester, Minnesota* 177

Calcification of the Supraspinatus Tendon: Infiltration Therapy with Local Anesthesia and Multiple Needling. *I. Norwich, M.B., F.R.C.S. (Edin.), Johannesburg, South Africa* 183

The Indication for Posterior Transpleural Bronchotomy in the Management of Intrabronchial Tumors. *Hiram T. Langston, M.D., F.A.C.S., Chicago, Illinois, and Robert T. Fox, M.D., Hines, Illinois* 192

Laryngectomy. *Louis H. Clerf, M.D., F.A.C.S., Philadelphia, Pennsylvania* 197

The Effect of Absorbable Sponge Materials on the Activity of Thrombin. *John H. Olwin, M.D., and Frederick J. Wahl, M.D., Chicago, Illinois* 203

CONTENTS CONTINUED ON PAGE 5

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Opponens Transplant: an Analysis of the Methods Employed and Results Obtained in Seventy-Five Cases. *John W. Kirklin, M.D., Rochester, Minnesota, and Colin G. Thomas, Jr., M.D., Iowa City, Iowa* 213

Treatment of Persistent Colon Bacillus Infections of the Urinary Tract by Sulfasuxidine and Streptomycin. *Edmund Crowley, B.S., M.D., F.A.C.S., and Vincent J. O'Conor, B.S., M.D., F.A.C.S., Chicago, Illinois* 224

The Radical Treatment of Brain Abscess. *Jerzy Chorobski, M.D., and Adam Kunicki, M.D., Warsaw, Poland* 230

EDITORIALS

Congenital Anomalies. *William E. Ladd, M.D., F.A.C.S., Boston, Massachusetts* .. 247

Congenital Anomalies of the Female Reproductive Organs. *Emil Novak, M.D., F.A.C.S., Baltimore, Maryland* 249

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

Gynecological and Obstetrical Pathology with Clinical and Endocrine Relations. 2d ed. By Emil Novak 253

Practical Physiological Chemistry. 12th ed. By Philip B. Hawk, Bernard L. Oser, and William H. Summerson 253

The Development of Inhalation Anesthesia; with Special Reference to the Years 1846–1900. By Barbara M. Duncum .. 254

Histopathology of the Ear, Nose and Throat. By Andrew A. Eggston and Dorothy Wolff 254

A Manual of Fractures and Dislocations. By Barbara Bartlett Stimson 255

A Handbook for the Diagnosis of Cancer of the Uterus by the Use of the Vaginal Smears. By Olive Gates and Shields Warren 255

The Rotunda Hospital 1745–1945. By O'Donel T. D. Browne 255

Anatomia Quirurgica del Nervio Facial. By Vicente J. Bertola 256

Books Received 256

INTERNATIONAL ABSTRACTS OF SURGERY

Contents ..... i-viii

Collective Review: Thiouracil and Its Allies in the Treatment of Hyperthyroidism; an Experimental and Clinical Survey. *George M. Curtis, M.D., and Roy E. Swenson, M.D., Columbus, Ohio* 105

Abstracts of Important Contributions in the Current Surgical Literature 124–208

New Non-Crushing Duodenal Clamp

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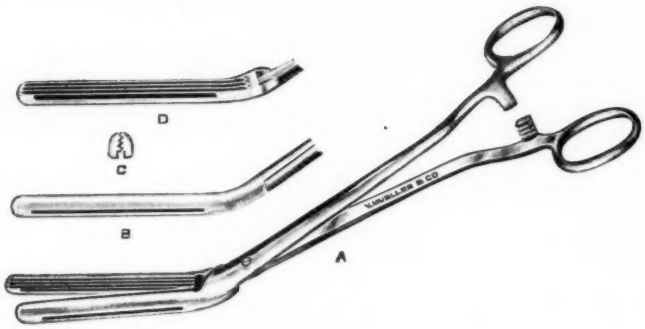

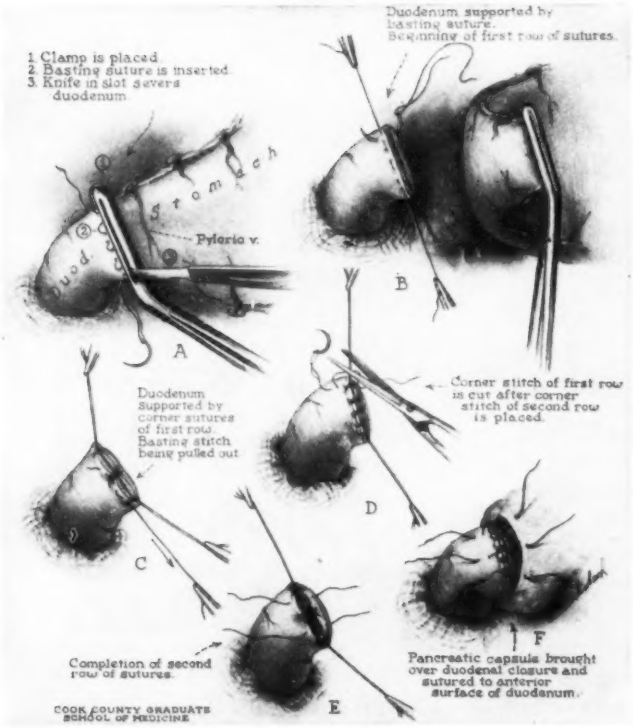
1. Clamp is placed.
2. Basting suture is inserted.
3. Knife in slot severs duodenum.
Stomach
Pylorus v.
Duod.
A
Duodenum supported by basting suture. Beginning of first row of sutures.
B
Corner stitch of first row is cut after corner stitch of second row is placed.
Duodenum supported by corner sutures of first row. Basting stitch being pulled out.
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